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Assessing Industry-Critical Skill Development in Engineering Technology Capstone Courses*

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To meet industrial expectations, engineering and engineering technology (ET) graduates are expected to possess the critical competencies of design, problem-solving, communication, and teamwork. However, industry stakeholders and academic studies routinely identify these as skills gaps: areas graduates need to develop to a higher standard or are currently lacking when entering the work force. To address this issue, many undergraduate programs in the United States have implemented a comprehensive and integrative experience at the end of an academic program, often called a capstone course(s). The rate of adoption has grown such that approximately three-quarters of all undergraduate and graduate institutions include capstones. This case study describes how an engineering design focused capstone impacted ET students' competencies (i.e., related knowledge, skills, and abilities). Central to the two-course sequence was an authentic learning experience that required students to follow the engineering design process to solve an internally or externally sourced open-ended problem. Forty-four students from two cohorts over two consecutive years strongly indicated that they had made progress in improving their design, problem-solving, communication, and group/teamwork competencies as a result of taking capstone.

Keywords: engineering technology; capstone; competency; skill gap; design

1. Introduction

1.1 Capstone Defined

A capstone (senior design) course is a culminating educational experience in which students apply engineering design and professional skills to a significant project, often serving as the primary vehicle for design instruction [1, 2]. Capstones are widely understood to be critical in preparing students to transition from school to work [3, 4]. Their essential role in the professional formation of engineering students is recognized by the Accreditation Board for Engineering and Technology (ABET), which requires a capstone as part of all engineering and ET baccalaureate curricula, that "develops student competencies in applying both technical and non-technical skills in solving problems" [5, p. 6]. As such, capstone experiences have become a near-ubiquitous element of undergraduate engineering education [6].

Five elements are recognized as contributing to capstone curricula:

- Engage in sustained project-based learning (PBL) [1, 7] and inquiry-based [8], often lasting an academic year [9]. PBL has been shown to positively influence students abilities to transfer knowledge, skills, and abilities (KSA) to new contexts, support collaborative work, improve retention, and enhance design thinking [1].
- Draw on real-world problems relevant to the discipline, that are open-ended, and give students experience with ill-structured, i.e., divergent [1], problem solving. By contextualizing the problem within a field of practice, students participate in situated learning [10], helping students develop the skills necessary to "address messy problems in realistic context" [11, p. 91].
- Immerse students in professional practice. By applying KSAs in environments reflecting real-world practice, students "apply life-long learning, engineering judgment, analytical decision-making, and critical thinking to address complex problems under a spectrum of social, environmental, and economic constraints" [3, p. 197], and aids them in "developing a robust understanding of what it means to be an engineer" [12, p. 632].
- Require public presentation of work. Reporting of design processes and products in both written and oral forms have consistently been reported to be in the top five topics covered in capstone design courses [9]. Such presentations are "opportunities for students to gain experience in situations they were likely to encounter in the workplace; to obtain professional feedback on their work" [3, p. 208].
- Use team-based work environments. Howe and Goldberg [6], report a historical average capstone team size of between three and five students. This

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reflects the notion that "design is an inherently social and human activity" [13, p. 636]. Additionally, collaborative learning methods like team-based capstones have been shown to produce greater gains [14].

Collectively these attributes describe an authentic learning experience; a real-world problem contextualized in the field of practice, reflective of how KSAs are applied in the workplace [15]. Such practice has been identified as aiding student development of "a richer understanding of the target knowledge domain, including a sense of how to approach challenges that they will encounter in the field" [16, p. 607]. Herrington, et al. [15], point out that it is critical for authentic learning to utilize authentic tasks: the learning environment needs to provide ill-defined tasks that have real-world relevance, and which present a single complex task to be completed over a sustained period of time. Additionally, the task must be presented in a context that reflects the way knowledge will be used in real life [15]. Thus, design projects are central to the capstone experience and are the primary component by which an authentic engineering learning experience is created (see Fig. 1); serving as the link by which engineering design [1, p. 104], capstone learning objectives [3, p. 203], and authentic learning [17, p. 564, 18, p. 2] are connected.

1.2 ET Capstones

A small body of work specifically addresses capstones in ET programs. The majority of relevant articles qualitatively summarize projects [19–21]. Others have investigated pedagogical issues of capstone in ET and address five themes:

- Capstones for data collection related to programmatic assessments, most commonly ABET. [22–25].
- Introducing industry methods into the classroom, such as product development processes and project management tools [26–28], entrepreneurial techniques [29] and methods specific to the electric power industry [30].
- Identification of predictive factors of successful achievement of course or project outcomes. Findings in this area identify optimal course structures, such as time requirements for capstone courses [31], and team composition as it relates to project type [32]. Others have looked at student characteristics, such as the effects of prior industry experience [33], students seriousness of purpose [34], or how performance on early course work predicts future performance [35].
- The effect of capstone on the work-readiness or professional skills of ET students. ET capstones have been shown to improve ET students' self-learning as measured via self-reporting [36] and to have a positive impact on increasing student confidence, motivation, and expectation of success in conducting engineering design [37].
- Team dynamics in capstone courses, such as identifying and measuring teamwork dimensions using online software [38] and how such data can be used to perform assessments of individuals for group assignments [39].

1.3 Capstones and Career Readiness

"Historically capstone design courses have often been charged with supporting students' transition to the workforce by providing authentic industry-oriented experiences" [40, p. 1]. In 1994, the first nationwide survey of engineering capstone courses

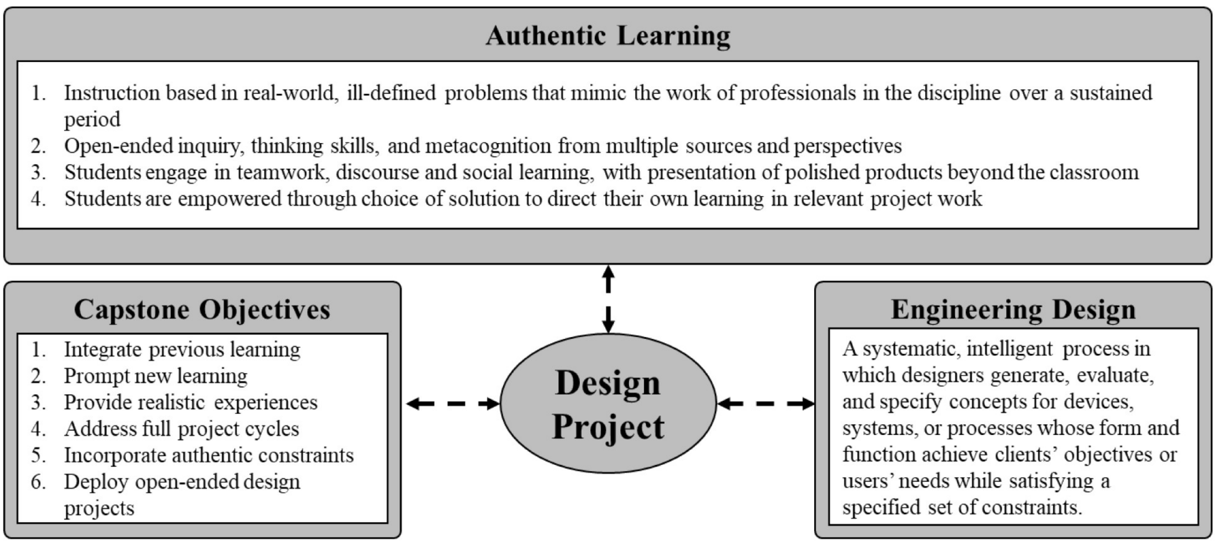

Fig. 1 Capstone as an Authentic Engineering Design Learning Experience.

found that projects were sourced generally evenly between external (59%) and internal (58%) sponsors [41]. Ever since there has been a clear trend in favor of industry. Howe, et al. [9], report the use of industry-sourced projects has grown to 71% and 80% in 2005 and 2015, respectively. Whatever the motivation, the prevailing approach to project sourcing in capstone is perhaps best summarized by Dym, et al. [1], "the capstone course has evolved over the years from made up projects devised by faculty to industry-sponsored projects where companies provide real problems, along with expertise and financial support" [1, p. 103]. Similar observations are made by Goldberg, et al. [42, p. 1] and Brackin, et al. [43, p. 1165].

The transition to industry-sourced capstone projects was partly a response to decades of feedback published by industrial advisory boards [44], professional associations [45, 46], and corporate councils [47, 48], regarding the competencies engineering and ET students should possess upon graduating. For example, the National Association of Colleges and Employers lists eight competencies for a career-ready workforce: career and self-development, communication, critical thinking, equality and inclusion, leadership, professionalism, teamwork, and technology [45]. Results from their recent 2023 job outlook survey compared the importance of competencies to employers with recent graduate proficiency and identified communication as having the largest gap amongst all eight (i.e. highly important but significantly lacking).

1.4 Study Purpose

Capstones have become nearly universal in engineering and ET undergraduate programs [6] with "70–80 percent of US higher education institutions offering them" [49, p. 143]. Despite the ubiquity of capstones in ET programs specifically, there is a paucity of research characterizing their current state, pedagogical effectiveness, and their ability to aid in developing/improving critical competencies. For example, ET programs were not included in recent works which studied the current state of capstone design pedagogy [50], the development of a recent functional taxonomy of capstone design teaching [3], and the competency gap of new engineering graduates from capstone to work [40, 51].

The purpose of this work is to add to the body of knowledge specifically concerning ET capstone experiences and to explore how an ET capstone experience impacted ET students' design, problem-solving, communication, and group/teamwork competencies.

2. Methodology

The study design is an exploratory research case study, a form of qualitative research "that investigates a distinct phenomenon, in which the there is a lack of detailed preliminary research, especially formulated hypotheses that can be tested, and/or by a specific research environment that limits the choice of methodology" [52, p. 373]. The results and observations from this preliminary case study will be used to develop a follow-on study(ies) with the necessary research questions and/or hypotheses for specific and focused casual research.

2.1 Research Site, Participants, Projects, and Setting

The case study was conducted at Purdue Polytechnic New Albany (PPNA), one of nine Polytechnic Institute's statewide sites (i.e. satellite campuses) that predominately provide local access to a Purdue degree in fields of study that are in high demand from regional and state employers. Study data was collected at the conclusion of an undergraduate multidisciplinary, team-based capstone consisting of two courses: ENGT48000 (ET Capstone I) and ENGT48100 (ET Capstone II). Both courses are required for all School of Engineering Technology (SoET) students majoring in Mechanical Engineering Technology (MET), Electrical Engineering Technology (EET), Industrial Engineering Technology (IET), Mechatronics Engineering Technology (MHET), and Engineering Technology (ET) at PPNA. During the study period, the instructors of record for Capstone I and II were an associate professor of EET and an associate professor of MET, who had co-taught PPNA's capstone courses for the previous six years.

Capstone I is exclusively offered during the Fall semester, and Capstone II during the Spring semester. Although Capstone I is not formally designated as a prerequisite for Capstone II, it is strongly recommended to complete both courses sequentially. This recommendation primarily stems from the central objective of the two-course sequence, which involves guiding students through the application of the engineering design process to address a single, complex, loosely structured, and open-ended project (i.e. project-based learning), concluding with the delivery of engineered products and/or processes to a customer. Detailed course descriptions and course learning outcomes (CLOs) are provided in Table 1.

Design projects for the course were solicited from industry/community-partners (industry-sponsored) and internally to the college (internally-sponsored) each summer prior to Capstone I. Sources of

Table 1. Course Descriptions and CLOs

Course	Description	CLOs
ENGT48000[1]	The skills needed to define, design, and develop engineering technology solutions are introduced and developed. Planning and designing alternatives that meet cost, performance, and user-interface goals are emphasized. Project planning, scheduling, and management techniques are studied. Different design approaches are compared. Teamwork, global and societal concerns, and professional ethics are integrated into course projects.	• Apply the engineering design process to engineering technology problems. • Evaluate customer needs when defining a solution • Determine a preferred solution. • Define and develop a plan for implementing a technical solution.
ENGT48100[2]	The focus of the course is on designing and implementing an acceptable solution.	• Participate effectively in teams. • Use appropriate research and discipline processes to design a solution. • Develop a final project report, properly acquiring, using, and citing sources. • Identify limitations and improvements as well as strengths of the design solution. • Present final solution recommendations.

Notes. [1] Fall semester; [2] Spring semester.

industry-sponsored project connections include industry, university alumni, Indiana Chamber of Commerce, companies in attendance at PUNA's bi-annual career fair, and using the school's social media. Internal projects were solicited from the school's ET faculty. In both cases, a call for project proposals provided course descriptions, objectives, partnership requirements, and typical project outcomes including prior student work samples. Submitted proposals were evaluated for selection by a committee of faculty based on the established criteria. Accepted projects were organized into a project catalog containing details about the project sponsor, a project description provided by the sponsor and edited by the faculty, contact information for the project mentor (industry engineer if industry-sponsored or faculty if internally-sponsored) and an estimate for the number of students and associated majors needed (e.g., 2 EET, 1 IET, 1 MET). During the first two weeks of Capstone I, the project catalog was presented to the students. A project interest survey was used to enable students to express their preferences for project selection such that students were matched with projects aligning with their personal interests and career goals. Prior use of this method has resulted in project teams matching students to one of their top three choices.

To manage the engineering design projects a stage-gate framework was applied (see Table 2). As described by Yang, et al. [53] each stage encompasses one or more steps of the engineering design process. At each gate, teams presented deliverables for review and evaluation, and received feedback from the capstone instructional faculty and other

Table 2. Engineering Design Process Overview

Course	Stage Gate	Description	Stage Gate Deliverables
ENGT48000	1 (weeks 1–6)	Project Proposal	• Oral Presentation. • Written Report. • Self and Peer Evaluations.
	2 (weeks 7–11)	Conceptual Design Review	• Oral Presentation. • Written Report (update). • Self and Peer Evaluations.
	3 (weeks 12–16)	Preliminary Design Review (PDR)	• Oral Presentation. • Written Report (update). • Self and Peer Evaluations. • Proof of Concept Prototype.
ENGT48100	4 (weeks 1–5)	Critical Design Review (CDR)	• Oral Presentation. • Written Report (update). • Self and Peer Evaluations. • Technical Data Package (TDP).
	5 (weeks 6–10)	Engineering Prototype	• Oral Presentation. • Revised TDP. • Self and Peer Evaluations. • Initial Engineering Prototype.
	6 (weeks 11–16)	Public Design Showcase	• Poster. • Written Report (update). • Self and Peer Evaluations. • Refined Engineering Prototype.

stakeholders (project customers/sponsors, project faculty mentors, etc.) Additionally, each team completed an anonymous peer review and feedback process in the areas of commitment, communication, KSAs, focus, and standards. This process has been shown to be highly effective at helping to facilitate engineering capstone teams via feedback to students, as a screening tool for instructors, and as a basis for team performance discussions between instructors and student team [54]. Historically, the stage-gate process for project management, combined with team performance surveys, has been proven effective in assisting student projects in achieving their objectives and successful completion.

2.2 KSA Assessment Instrument

To assess students' perceived general design, problem solving, communication, and teamwork competency development, the study used part three of the four-part Classroom Activities and Outcomes Survey (CAOS), see Appendix for all survey items. The National Science Foundation (NSF) supported survey was developed by the Center for the Study of Higher Education at Pennsylvania State University as part of the evaluation of Engineering Coalition of Schools for Excellence in Education and Leadership [14, 55, 56]. The indirect assessment tool measures the extent to which students believe they have or have not made progress in a variety of engineering related skills, as a result of taking the course(s). Terenzini, et al. [14] performed a factor analysis on the original 24 survey items which produced the four general content areas of design, problem-solving, communication, and teamwork.

The CAOS was converted to an online survey (Qualtrics) by the authors and distributed to students via the course learning management system (Brightspace) using an announcement during the final week(s) of the semester. Participation was voluntary and multiple attempts/submission were prevented via Qualtrics settings.

3. Results

3.1 Study Demographics

The case study population consisted of students from ENGT48100, Capstone II at PPNA during the spring semesters of 2022 (N = 35) and 2023 (N = 16). The CAOS was completed by 32 students (91.43%) in 2022 and 13 (81.23%) in 2023. One 2022 respondent was removed from the data set as they had not completed ENGT48000 the preceding semester. (i.e. did not complete Capstone I and II sequentially). The convenience sample consisted of 44 students, 31 from cohort 1 and 13 from cohort 2.

All participants in the sample were classified as seniors as determined by credit hours completed. Six (13.64%) students identified as female and 38 (86.36%) as male. Thirty-seven (84.09%) were between 18–25, five (11.36%) between 26–34, and two (4.55%) between 35–54 years of age, respectively. Forty identified as White (90.91%), three as Hispanic/Latino (6.82%), and one as Black or African American (2.27%). Finally, twenty-one (47.73%) students majored in MET, thirteen (29.55%) in EET, seven (15.91%) in MHET, two (4.55%) in ET, and one (2.27%) in IET.

Cohort 1 consisted of six teams with a median number of six students (minimum 5; maximum 7) on each and cohort 2 consisted of three teams with a median number of six students (minimum 4; maximum 6) on each. Each team was multidisciplinary, and projects were primarily industry-sourced (one faculty-sourced project per cohort). Each team successfully progressed through the engineering design process and submitted all required stage gate deliverables (see Table 2). See Table 6 in Appendix for a sample of project descriptions, requirements, and final prototype. The average final grade for cohort 1 was 86.66% and cohort 2 was 76.74%.

3.2 CAOS Data

Because the study data was collected across two cohorts, a Shapiro-Wilks test of normality was applied (see Table 3). Because the competency area means cannot be assumed to be normally distributed, a Lavene's test for equality of variance was applied. As shown in Table 4, five of the 24 survey items have a p-value suggesting unequal variances between the cohorts. Based on these results and the small sample size of cohort 2 (n<35) the non-parametric Kologorov-Smirnov test was applied. It was found that the distribution of means for each competency level did not significantly change between the cohorts and relative effect sizes were trivial (KS <0.1).

Table 5 presents the descriptive statistics of the CAOS data, both per team and combined. Based on the self-reported CAOS data (1 = none at all; 4 = a great deal), on average and across both cohorts, the

Table 3. Shapiro-Wilk Test of Normality

	Cohort 1	**Cohort 2**
	Spring 2022	Spring 2023
Competency Area	Sig. (Statistic)	Sig. (Statistic)
• Design	**0.013 (0.910)**	0.078 (0.883)
• Problem-Solving	0.063 (0.936)	**0.022 (0.842)**
• Communication	**0.004 (0.893)**	**0.027 (0.848)**
• Group/Teamwork	**0.024 (0.920)**	0.212 (0.915)

Notes. $\alpha < 0.05$.

Table 4. Levene's Test of Homogeneity: Items w/ Significant Variance

Survey Item	**Sig. (Statistic)**
• Your knowledge and understanding of the language of design in engineering	0.041 (4.459)
• Your ability to identify the knowledge, resources, and people needed to solve an unstructured problem	0.033 (4.864)
• Your ability to evaluate arguments and evidence so that the strengths and weaknesses of competing alternatives can be judged	0.017 (6.213)
• Your ability to develop ways to resolve conflict and reach agreement in a group	0.019 (5.931)
• Your ability to pay attention to the feelings of all group members	0.036 (4.682)

Notes. $\alpha < 0.05$; based on means.

Table 5. Means per Competency Area

	Cohort 1	**Cohort 2**	**COMBINED**
	Spring 2022	Spring 2023	
Competency Area	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
• Design	3.32 (0.60)	3.35 (0.36)	3.33 (0.53)
• Problem-Solving	3.31 (0.54)	3.28 (0.40)	3.30 (0.49)
• Communication	3.10 (0.81)	3.19 (0.52)	3.13 (0.73)
• Group/Teamwork	3.24 (0.66)	3.35 (0.48)	3.27 (0.61)

Notes. 1 = none at all, 2 = a slight amount, 3 = a moderate amount, and 4 = a great deal.

students reported that they had moderately to greatly improved their design (M = 3.33), problem-solving (M = 3.30), communication competencies (M = 3.13), and group/teamwork competencies (M = 3.27), as result of taking the course (see Table 5).

4. Discussion

Analysis of the individual CAOS survey items (see Table 7 in Appendix) shows that the skill *Your ability to do design* exhibits a lower mean and higher standard deviation than the other skills evaluated. These results can be seen as incongruent with the description of engineering design provided in Fig. 1, in which teamwork, problem solving, and communication are constituent components of engineering design. The results indicate a potential discrepancy between students' understanding of design principles and their perceived ability to apply them practically, suggesting a possible narrow perception of design that excludes certain factors.

4.1 Study Limitations

Generalizations from this study are limited due to multiple factors; the inherent concerns with exploratory case studies (e.g., participants' truthfulness, researchers' bias, no manipulated variable) [57], small samples and homogenous demographics [58]. Additional limitations to note include the multiple uncontrollable variables between each cohort (e.g., differing skill levels at entry, subjective grading, improved instruction over time), participants were not random (i.e. convenience sample), the use of indirect over direct assessment methods, and the one of the authors being an instructor of record. It should be noted that the classroom activities and outcomes survey was published and validated in 1998 [59, 60] and has since been used in multiple published studies [61–66].

4.2 Future Work

Despite the limitations, this exploratory case study has been valuable for gaining a deeper understanding of a complex situation/environment, generating future research areas/questions, and providing rich and context-specific insights. This work also contributes to the recent call by Streveler and Menekse [67] for "the engineering education community to take a more nuanced approach to active learning. Instead of asking, does active learning work? One can now ask, what kind of active method produces the highest learning in specific settings, or with specific kinds of students?" [67, p. 189]. While the findings of the study provide evidence of the benefit of capstone to student's industry critical skills, specific pedagogical approaches were not evaluated. Two factors of interest are course structure and project type.

This work does not provide any insight into which stage gate(s) and/or specific factors of capstone (e.g., engineering design process, project source, etc.) impacted ET students' competencies the most or least. Future work will compare CAOS data between Capstone I (stage gate 3) and Capstone II (stage gate 6) to analyze if competency impact was due in part to the sequential two course capstone experience or not. Any opportunity to reduce the length of a capstone experience without compromising the development of students' professional competencies that industry is demanding should be explored.

Additionally, the projects used in this study were complex and ill-defined (see Fig. 1), the norm in recent decades for capstones. Such projects are often challenging for capstone stakeholders (e.g., students, faculty, staff, sponsors, etc.) and can negatively impact student learning. Confounding issues include unrealistic expectations by sponsors regarding the amount of work and level of quality that is to be delivered by the student team as well as expectations not matching with course requirements [42].

Additionally, the mentorship provided by industrial sponsors (if included) is often of varying quality and can be detrimental to the students' learning experience. Appiah-Kubi, et al. [68], cite negative impacts to student motivation due to non-committed clients, while both Goldberg, et al. [42] and Milanovic and Eppes [69] observe negative impacts to project management, such as, lack of availability of sponsors when needed and changes to the scope of the project after the project definition. Milanovic and Eppes [69], go as far as to say that industry-sponsorship increases the probability of failure of the project. This can lead to cognitive overload, where students scramble to achieve results. Zhan, et al. [28] observe that "under pressure to deliver, many students may get frustrated with all the new tools they need to learn in order to follow the product development process and choose to use trial-and-error method to get immediate results, resulting in a project where the systematic product development process may not be practiced" [28, p. 34]. Future work will evaluate CAOS data with respect to the complexity and uncertainty of the design project assigned to student teams.

5. Conclusion

The integration of capstone courses in engineering and ET programs has emerged as a pivotal solution to address the skills gaps that graduates face when entering the workforce. As industry demands continue to evolve, the critical competencies of design, problem-solving, communication, and teamwork have become essential for success. This case study highlights the significant impact of an engineering design-focused capstone, which provided students with an authentic learning experience and the opportunity to apply the engineering design process to real-world, open-ended challenges. The feedback from forty-five students across two cohorts over two consecutive years strongly supports the notion that capstone courses contribute to substantial improvements in these crucial competencies. It is evident that these integrative programs are instrumental in preparing future engineers and ET professionals to excel in the dynamic and ever-changing field of engineering.

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Table 6. Project Examples

Title	Description	Project Requirements	Engineering Prototype
Power Plant Exhibit	Duke Energy Corp. proposed an interactive display to represent and preserve the history of the Gallagher Station, a coal-fired power plant decommissioned in 2021.	• Fit the size restraints of the New Albany Pagett Museum. • Entertain and educate visitors. • Durable enough to withstand time and movement. • Portable in order to take to other locations. • Use a non-zero number of parts from Gallagher Station.	
Robotic Training Program	PTG Silicones Corp. proposed a designated training cell in order to get new and existing workers training with in-house equipment currently in operation.	• Set up =< 15 minutes. • Set up =< 2 people. • Full load deflection < 14 inch. • Training program =< 2 hours. • Powered on = cell doors closed. • Wheel displacement during operation =< 1 inch. • Training program includes material handling exercise.	

Table 6. (*Continued*)

Title	Description	Project Requirements	Engineering Prototype
Electric Go-kart	PPNA solicited an electric go-kart that adheres to the rules and regulations of the 2022 evGrand Prix race. The kart was to be designed for high acceleration, velocity, torque, and cornering ability.	• Drive train = electric. • Lap time >= 35 seconds. • Battery life >= 10 minutes. • Battery change =< 60 seconds.	

Means per CAOS Survey Item

	Cohort 1	Cohort 2
	Spring 2022	Spring 2023
Competency Area	*M* (*SD*)	*M* (*SD*)
Design		
• Understanding of what engineers do in industry or as faculty members	3.35 (0.66)	3.38 (0.51)
• Understanding of engineering as a field that often involves non-technical considerations (e.g., economic, political, ethical, and/or social issues)	3.39 (0.62)	3.38 (0.51)
• Knowledge and understanding of the language of design in engineering	3.29 (0.78)	3.38 (0.51)
• Knowledge and understanding of the process of design in engineering	3.55 (0.57)	3.38 (0.51)
• Your ability to do design	3.00 (0.93)	3.23 (0.60)
Problem-Solving		
• Your ability to solve an unstructured problem (that is, one for which no single "right" answer exists)	3.32 (0.70)	3.23 (0.60)
• Your ability to identify the knowledge, resources, and people needed to solve an unstructured problem	3.45 (0.72)	3.31 (0.48)
• Your ability to evaluate arguments and evidence so that the strengths and weaknesses of competing alternatives can be judged	3.23 (0.72)	3.08 (0.49)
• Your ability to apply an abstract concept or idea to a real problem or situation	3.23 (0.72)	3.31 (0.48)
• Your ability to divide unstructured problems into manageable components	3.32 (0.70)	3.50 (0.52)
Communication		
• Your ability to clearly describe a problem orally	3.13 (0.89)	3.15 (0.56)
• Your ability to clearly describe a problem in writing	3.06 (0.85)	3.23 (0.60)
Group/Teamwork		
• Your ability to develop ways to resolve conflict and reach agreement in a group	3.13 (0.99)	3.23 (0.60)
• Your ability to pay attention to the feelings of all group members	3.23 (0.88)	3.08 (0.64)
• Your ability to listen to the ideas of others with an open mind	3.32 (0.83)	3.54 (0.52)
• Your ability to work on collaborative projects as a member of a team	3.32 (0.79)	3.46 (0.66)
• Your ability to organize information into categories, distinctions, or frameworks that will aid comprehension	3.26 (0.73)	3.46 (0.52)
• Your ability to ask probing questions that clarify facts, concepts, or relationships	3.19 (0.70)	3.31 (0.63)
• After evaluating the alternatives generated, to develop a new alternative that combines the best qualities and avoids the disadvantages of the previous alternatives	3.23 (0.81)	3.38 (0.65)
Other, Unscaled Items		
• Your ability to develop several methods that might be used to solve an unstructured problem	3.26 (0.68)	3.54 (0.52)
• Your ability to identify the tasks needed to solve an unstructured problem	3.23 (0.72)	3.31 (0.48)
• Your ability to visualize what the product of a project would look like	3.35 (0.80)	3.23 (0.60)
• Your ability to weigh the pros and cons of possible solutions to a problem	3.39 (0.76)	3.38 (0.65)
• Your ability to figure out what changes are needed in prototypes so that the final engineering project meets design specifications	3.29 (0.64)	3.38 (0.51)

Notes. 1 = none at all, 2 = a slight amount, 3 = a moderate amount, and 4 = a great deal.

Rustin Webster, PhD is an associate professor in the Purdue Polytechnic Institute at Purdue University and specializes in mechanical engineering and computer graphics technology. Prior to academia, he worked for an aerospace and engineering company as a mechanical engineer, product development lead, and researcher. Dr Webster designed various solutions for multiple branches of the Armed Forces, the Department of Defense, and the National Aeronautics and Space Administration. He holds a BS in Engineering Graphics and Design and a MS in Management of Technology from Murray State University, and a PhD in Interdisciplinary Engineering from the University of Alabama at Birmingham. Dr. Webster is a certified GD&T-Technologist, SOLIDWORKS Expert, and Six Sigma Green Belt. For his teaching and mentoring of students he has been awarded the American Society for Engineering Education (ASEE) Engineering Technology (ET) National Teaching Award, Purdue University Teaching Academy Fellowship, School of Engineering Technology Outstanding Faculty in Teaching and Learning Award (twice), Purdue Teaching for Tomorrow Fellowship, Purdue Teaching Academy Pandemic Teaching Award, ASEE Engineering Graphics and Design Rising Educator Award, and SME Distinguished Faculty Advisor Award (twice). Dr Webster's research interests include ET design education with focus areas in computer-aided design (CAD) and pedagogy.

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