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AI Trends in Industry-Sponsored Capstone Design

Edward Latorre, University of Florida

Dr. Edward Latorre is an Engineer (instructional professor) with the Department of Engineering Education at the University of Florida and the Director of the Integrated Product and Process Design (IPPD) program. His current research areas are in support of his teaching in IPPD, an interdisciplinary senior and graduate level design course sequence where student teams develop solutions for industry sponsored projects. https://eed.eng.ufl.edu/people/faculty/name/edward-latorre-navarro/

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Abstract

Artificial intelligence (AI) is a topic in every conversation involving technology, including in research, academia, industry, and mainstream applications. Hence, academia, industry and government organizations are collaborating in preparing the current and incoming workforce to both, develop AI technologies, and apply AI solutions towards technological advancements. These collaborations include sponsoring capstone design courses, which for decades have helped prepare students to join the workforce well-prepared for immediate contribution. As the push for AI applications rapidly intensifies, one question that arises is, how has the distribution of AI project themes in these partnerships changed over the past years? To help answer this question, this paper presents an analysis of how AI is influencing the scope of sponsored capstone projects at various engineering programs. Considering the recent era of mainstream AI, the analysis covers the six academic years 2019-20 to 2024-25, through data collected from the public websites of ten industry-sponsored capstone courses from universities across the USA. The data showed that the number of AI-related projects nearly doubled, while the relative proportion of AI-related projects increased by 43%. A measure of the unweighted mean of the AI-related projects for all programs for each of the six years showed significant growth in the adoption of AI-related projects from 9.7% in 2019 to 17% in 2024. Overall, all these programs have managed AI-related projects, and most of them had a positive adoption rate and a positive median slope, thus suggesting a positive yet broad institution-level growth trend. However, the growth is moderate compared to widespread reports on AI investments across the nation. Noticeably, most programs had a drop in AI-related projects around 2022 and 2023, but in 2024 the rise in AI-related projects was shared across institutions.

Introduction and Motivation

As defined by the Triple Helix model of university-industry-government relations, the carrying functions of a knowledge-based economy are specified as (1) economic wealth generation, (2) knowledge-based novelty production, and (3) normative (e.g., political) control [1]. Recent advancements in AI-related technologies and their application to technological advancement can be situated within this model where universities contribute the knowledge-based novelty production, industries drive the economic wealth generation, and government provides (developing) normative and policy control, thus collectively shaping the generation of an AI-ready workforce.

The AI domain requires that recent graduates and current professionals rapidly acquire practical skills and competencies in areas such as data engineering, data science, decision making and ethical and effective use of AI-related generative tools [2]. Given the recent fast-paced development and adoption of AI-related technologies, all three pillars of this Triple Helix model find themselves trailing the market demands [3,4,5]. Notwithstanding, this demand is slowly pushing a growing trend in strategic partnerships between academia and industries towards the development of an AI-ready workforce, and thus also generating progress in the integration of AI into higher education and university research. Some examples include defining new “future

skills", research areas, and learning models, and supporting technological infrastructure, collaborative research, internships, and professional development [6].

In engineering and computer science fields, a longstanding approach for industries and academia to collaborate in the formation of professionals is through capstone courses, such as those where students work on design teams for industry-sponsored projects [7]. Among their many objectives, these institutionally designated real-world project development courses integrate advanced technical skills, system-level competencies, social perspectives, and ethical considerations, thereby preparing students to meet the demands of their respective domains, even in complex and rapidly evolving areas such as artificial intelligence. Accordingly, given the recent market demands, should we expect a correspondingly strong level of industry interest in sponsoring AI-related projects?

This paper examines current trends in the offering of AI-related projects within industry-sponsored engineering capstone design courses. The results presented in this paper represent an exploration of how the rise of AI technologies is shaping industry-sponsored capstone courses offered at engineering and computing programs.

Research Question

To what extent have recent developments in AI influenced academia-industry collaborations within capstone courses over the past six years?

Methodology

A quantitative study was developed to examine the distribution of AI-themed projects across a sample of ten engineering capstone programs in North America. The first step was to identify academic institutions that offered engineering and computer science industry-sponsored capstone design courses. Institutional sampling was guided by geographic location, student enrollment size, and research classification. Institutions were selected if they had a public website of the course that lists the academic disciplines they serve and their past industry-sponsored projects, including the respective academic terms, sponsors, and project titles. This project data was scrapped from these websites. This data was then classified as either AI-related or non-AI-related and analyzed to identify overall trends in the offering of the AI-related projects.

AI-related projects were classified based on keyword matching applied to the project titles. The keywords were derived from a semantic network centered on the term artificial intelligence, created by reviewing several academic courses, web search engines, and commercial generative AI assistants. The network was designed to be initially exhaustive and then iteratively pruned by visual inspection during keyword matching to minimize false positives. The resulting Keywords are listed below.

Keywords = AI, analytics, assistant, autonomous, chatbot, data-driven, detection, generative, intel, knowledge, language, learn, LLM, ML, neural, pattern, predict, recognition, reinforcement, sentiment, smart, twin.

The following limitations during this keyword matching process were identified.

1. The capitalized terms AI, LLM and ML were searched as exact terms. The other terms were searched as tokens, allowing for partial matches, e.g. “learn” also matches with “learning”.
2. The words “analytics”, “detection”, “language”, “learn”, and “neural” generated false positives, which were identified and pruned through the visual inspection.
3. False positives might still exist due to misinterpretation or ambiguity of the project title during the visual inspection.
4. An unknown number of false negatives remain because some project titles did not match the Keywords though made use of AI-related technology.
5. Additional false negatives might also exist if any significant AI-relevant words were omitted from the Keywords list.

Data Collection and Results

This paper includes data obtained from ten institutions based on the requirements listed above. Ideally, the search would have provided ten programs with project data for the 2019 – 2025 period of interest, however, only five were obtained. Five additional programs were included, three of which had data for 2020 – 2025, and two which had data from 2021 – 2025. These ten institutions are in the USA, specifically four in the Northeast area, three in the West area, two in the Southeast area, and one in the Midwest area. Seven of these institutions have a Carnegie classification of R1, while the other three are classified as R2. Their engineering enrollment ranges from approximately 500 to 21,000 students. Eight programs have two-semester course sequences, while the other two have a one-semester course.

As the goal is to view overall trends rather than evaluate institutions, the data were de-identified before analysis and for the presentation of this paper. However, researchers can readily replicate the analysis by matching the data with the listed references [8] – [17]. Table 1 lists the data collected from each institution. Two programs have a minority of students that are not from engineering disciplines.

Table 1. Data Collected from the Capstone Programs from each Institution

Institution (distinction noted)	**Disciplines (Engineering or as noted)**	**Academic Years**	**Number of Sponsored Projects per Year**	**Number of Projects Leveraging AI**
U1	Electrical & Computer Manufacturing Mechanical Cybersecurity	2024-25	55	8
		2023-24	52	5
		2022-23	56	4
		2021-22	50	4
		2020-21	53	7
		2019-20	54	1
U2 *2 cohorts per year	Aerospace Biomedical Civil	2024-25	207	6
		2023-24	211	8

Institution (distinction noted)	Disciplines (Engineering or as noted)	Academic Years	Number of Sponsored Projects per Year	Number of Projects Leveraging AI
(cont. U2)	Electrical & Computer Industrial & Systems Industrial Design Mechanical Materials	2022-23	192	10
		2021-22	224	6
		2020-21	210	13
		2019-20	N/A	
U3	Computer Science Engineering (multiple concentrations) Mathematics Physics	2024-25	45	9
		2023-24	45	8
		2022-23	41	6
		2021-22	46	7
		2020-21	43	7
		2019-20	56	8
U4 *Includes some non-capstone multidisciplinary design projects, and projects from engineering design student clubs.	Biomedical Chemical & Biomolecular Civil Electrical & Computer Computer Science Environmental Health Materials Mathematics	2024-25	164	27
		2023-24	121	19
		2022-23	105	21
		2021-22	171	29
		2020-21	154	22
		2019-20	N/A	
U5	Computer Electrical Mechanical Engineering (similar concentrations as above)	2024-25	13	2
		2023-24	13	0
		2022-23	13	1
		2021-22	11	0
		2020-21	11	0
		2019-20	14	2
U6	Biomedical Electrical & Computer Industrial and Systems Mechanical	2024-25	61	6
		2023-24	65	4
		2022-23	42	4
		2021-22	56	4
		2020-21	N/A	
		2019-20	N/A	
U7	Aerospace Biomedical Chemical Civil & Environmental Climate and Space Sc.	2024-25	33	14
		2023-24	33	9
		2022-23	29	8

Institution (distinction noted)	Disciplines (Engineering or as noted)	Academic Years	Number of Sponsored Projects per Year	Number of Projects Leveraging AI
(cont. U7)	Computer Science Electrical & Computer Industrial & Operations Materials Mechanical Naval Architecture & Marine Nuclear Robotics 30% are non-engineering	2021-22	33	9
		2020-21	34	8
		2019-20	N/A	
U8	Aeronautics & Astronautics Bioengineering Chemical Civil & Environmental Computer Science Electrical Computer Human Centered Design Industrial & Systems Materials Mechanical	2024-25	91	17
		2023-24	95	19
		2022-23	100	12
		2021-22	85	21
		2020-21	N/A	
		2019-20	N/A	
U9 *2 cohorts per year	Biomedical Computer Science Electrical & Computer Energy Industrial Materials Mechanical Engineering Design Engineering Science & Mechanics Data Science	2024-25	199	10
		2023-24	206	9
		2022-23	214	13
		2021-22	174	17
		2020-21	75	5
		2019-20	109	4
U10	Aerospace Biomedical Chemical Civil & Environmental Computer Science Electrical & Computer Industrial & Systems Materials Mechanical	2024-25	12	3
		2023-24	16	3
		2022-23	18	2
		2021-22	11	2
		2020-21	13	2
		2019-20	14	2

Data Analysis

Figure 1 shows the percentage of total number of AI-related projects for all ten programs over the six years. Note that, following Table 1, only five programs are included in 2019 and eight in

2020, thus the increase in 2020 and 2021 are also related to the inclusion of the additional five programs. Counting all ten programs and using only the years 2021-22 through 2024-25, for which all programs have data, the number of projects leveraging AI changed from 99 out of 861 to 102 out of 880, thus an insignificant adoption rate increase of 11.5% to 11.6%.

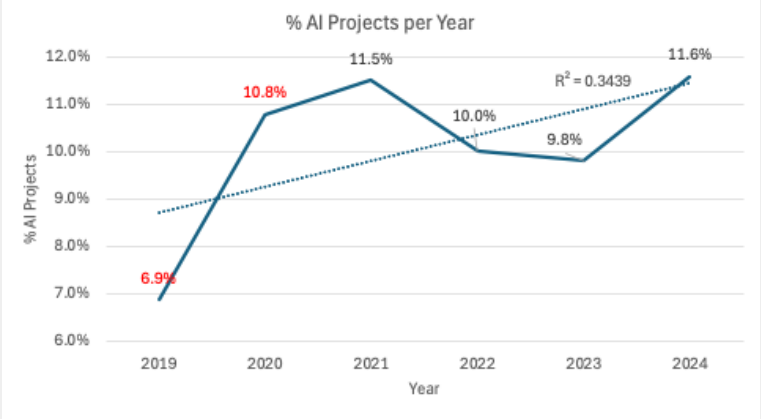

Figure 1. Total number of AI-related projects for all ten programs over the six years, except years 2019 that includes five programs and 2020 that includes eight programs.

To aid in identifying trends, the data was broken into two sets, those with the full six years and those with less than six years. Table 2 shows the yearly results counting only the five programs with data for all six years (U1, U3, U5, U9, and U10).

Table 2. Results for the Five Programs that had Six Years of Data

Years	Total Projects	AI-Related Projects	% AI
2019 – 2020	247	17	6.9
2020 – 2021	195	21	10.8
2021 – 2022	292	30	10.3
2022 – 2023	342	26	7.6
2023 – 2024	332	25	7.5
2024 – 2025	324	32	9.9

- Over the six-year period, the number of AI-related projects nearly doubled, while the relative proportion of AI-related projects increased by 43% (from 6.9% to 9.9%).
- For the four-year period 2021-2025, the number of projects leveraging AI reduced with an adoption rate decrease of 10.3% to 9.9%.
- The AI share had a significant dip in 2022 and then recovered in 2024, thus still not reaching the levels from 2020 and 2021. However, the count of AI projects in 2024 is much higher than in 2020 and slightly higher than 2021. The lower number of total projects in 2020 is most likely because of the effects of the COVID-19 pandemic. Similarly, the large jump in AI-related projects could be related to these programs encouraging software development projects given most personnel was working remotely. Under this assumption, the AI share decrease in 2022 through 2023 could be tied to an increase in hardware related projects as all personnel returned to campus, and more

likely, several industry limitations related to the post-pandemic economic contraction. Limitations such as, reduced budget for AI, decrease in AI-related hardware due to supply-chain contractions, shortage in AI-talent to ideate and supervise the projects, and regulatory and ethical disputes with the release of several high-profile AI tools.

Table 3 shows the yearly results counting only the five programs that did not have the six years of data, and considering only the four-year period 2021-2025 (U2, U4, U6, U7, and U8).

Table 3. Results for the Five Programs that had Less than Five Years of Data

Years	Total Projects	AI-Related Projects	% AI
2021 – 2022	569	69	12.1
2022 – 2023	468	55	11.8
2023 – 2024	525	59	11.2
2024 – 2025	556	70	12.6

- For the four-year period 2021-2025, the number of projects leveraging AI slightly increased with an adoption rate between 12.1% and 12.6%.
- Compared to the data in Table 2, the total number of projects significantly dipped in 2022, however the adoption rate barely dipped. Total projects bounced significantly in 2023, however the AI share dipped slightly more. By 2024 the number of total projects had increased to near the 2021 level, while the AI share was slightly higher than in 2021.

Additional insight is obtained by creating an institution-weighted (equal-weight) analysis, where for each academic year, each university's AI share (AI projects ÷ total projects) is calculated, to then determine the average of those shares across all universities that reported in that year. Figure 2 shows this year-by-year series, which reflects the trends over all the available programs.

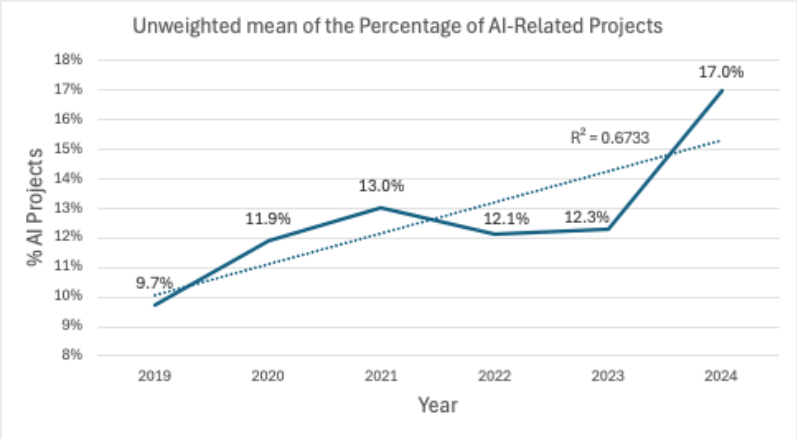

Figure 2. Unweighted mean of the AI-related projects for all programs for each of the six years.

The growth from 9.7% in 2019 to 17% in 2024 signals a significant growth in the adoption of AI-related projects. Figure 2 also shows the resulting linear trend and the respective coefficient of determination R^2, which is 0.67, suggesting moderate growth over the period. Measuring the dispersion (IQR) of AI prevalence across projects, in 2022 it was 6.7 pp, then widened in 2023 to

13.7 pp, and contracted again in 2024 to 8.7 pp. These measures suggest the rise in AI integration is broadly shared across institutions.

Additional observations from this analysis:

- Only three of the universities with sizable research departments showed a relatively moderate relationship between project volume and AI share, suggesting size can help, but is not a guarantee. Medium and small institutions displayed weak or inverse correlations.
- The near-constant total project count over the years suggests the increase in AI share relates to gains in AI-driven knowledge production, rather than an increase of projects amongst all topics including AI.

Conclusion

Overall, the data suggests that programs have experienced an increase in AI-related projects driven by the current market trends. Even with the common dip around 2022 and 2023, most courses show positive trend over time. However, the growth is moderate compared to widespread reports on AI investments across the nation. This increase could be higher than presented here considering the data has more false negatives than false positives. Perhaps the non-linear increase may have been more linear had the global pandemic of 2020 not occurred or through some of other reasons described above. These questions will be addressed in the continuation of this study, which is underway with surveys and interviews to examine how this trend is influencing students, curriculum development, and industries.

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