2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC
Host Sponsor UNC Charlotte
Paper ID #53718

Engineering for the Artificial Intelligence Demand: Curriculum Development of a New Artificial Intelligence Engineering Degree

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The opportunity to develop a completely new engineering curriculum is uncommon as many new undergraduate engineering programs are derivatives of traditional engineering disciplines. One area that provides such opportunity is artificial intelligence (AI). The field of AI has grown rapidly in the last decade. AI has impacted and will continue to impact all fields of knowledge, industry, government, and society, fundamentally changing the status quo. The body of knowledge and skills required to design, develop, and evaluate computation systems using AI technology requires a distinct set of courses from multiple disciplines. A recent survey found "artificial intelligence (AI) and machine learning are the most popular Ph.D. specialties among graduates in the computer science, computer engineering and information fields." This demand at the graduate level has begun to filter down to the undergraduate level as seen by the development of baccalaureate AI degrees at several peer institutions. Unlike these peer institutions with only one AI degree, Penn State University has decided that at least two AI degrees are needed to meet the student demand and interests, in addition to offering AI minors.

This paper describes the development of a new baccalaureate AI Engineering degree and associated minor that were designed to provide students with the mathematical and algorithmic foundations of AI techniques, along with hands-on experience using AI techniques and foundational models to design and construct software solutions to complex problems. The curriculum includes coursework in computer science, mathematics, statistics, computational modeling, machine learning, and symbolic computation. Students study algorithms, design and develop software systems, and apply this knowledge and experience to address applications of AI to complex problems. Complementing these engineering skills with a broader perspective is an understanding of the issues required to develop responsible AI that benefits society. Elective coursework allows students to focus on deeper topics, ranging from machine learning to vision and language. During the process, input from faculty, students, and industry worked to shape the contours of the novel program, melding areas of computer science, computational science, data science, electrical engineering, mathematics, and statistics to prepare program graduates to ethically and responsibly engineer artificial intelligence systems of the future. Challenges and opportunities from the curriculum development and deployment process are chronicled with a view of informing and encouraging similarly minded curricular innovations across the organizational field.

Key Words: computational thinking, curricular innovation, artificial intelligence curricula.

Introduction

The new Artificial Intelligence Engineering (AIE) degree described in this paper was designed to bridge the gap between the theoretical foundations of artificial intelligence (AI) and the engineering of AI-driven systems. What distinguishes this AIE degree is its focus on *engineering intelligence* rather than merely *applying AI*. The program prepares and empowers students to understand, design, build, and analyze AI-enabled systems from the ground up, mastering every layer from mathematical principles and learning algorithms to computing architecture and responsible, real-world deployment. It provides students with a strong grounding in mathematics, algorithms, and computational modeling, combined with extensive hands-on experience in applying AI techniques and foundational models to solve real-world problems. The curriculum integrates coursework across computer science, electrical and computer engineering, mathematics, statistics, and machine learning, offering a truly interdisciplinary foundation. On one hand, students gain exposure to AI-optimized microprocessors and semiconductor design, preparing those with hardware and systems interests to engineer the next generation of intelligent computing platforms, essentially, tomorrow's versions of the Graphics Processing Unit (GPU). On the other hand, the program equips software-oriented students with the knowledge and experience needed to develop advanced AI frameworks and foundational models, such as the future counterparts of Google TensorFlow or OpenAI's GPT. Through a combination of core courses, flexible electives, and project-based learning experiences, students learn to design, build, and deploy AI solutions that are efficient, trustworthy, and scalable. The AIE degree is a forward-looking educational pathway that unites AI algorithms, computing architectures, and responsible innovation, thus training a new generation of engineers ready to lead in the rapidly evolving AI landscape.

This work documents the curricular development process for the AIE program at Penn State, a large, public, multi-campus research intensive institution located in the northeast United States (U.S.). This paper advances the state of computing education by providing a model for successful development of new approaches towards computing education, with an eye fixed on program graduates' professional skills development, including preparing program graduates for modern engineering workplaces, engineering the future of intelligence in engineering practice.

Background

The field of artificial intelligence (AI) has grown rapidly in the last decade. AI has impacted, and will continue to impact, all fields of knowledge, industry, government, and society in ways that are fundamentally changing current processes and thought. AI is surging worldwide and especially in the (U.S.); indeed, AI is showing signs that it could reshape the global economy and viewed as the driver of the global economy [1]. Corporate demand for entry-level professionals at the baccalaureate level is high and largely unmet. Needed are interdisciplinary AI professionals, whose skills integrate literacies in artificial intelligence, computing, data science (DS), business, ethics, and specific subject areas such as health and finance. AI is also reshaping the labor market, marking a significant transformation in both the scope and the nature of employment and economic activities worldwide. In 2023, the global AI market was valued at approximately $196 billion and is projected to surge at a compound annual growth rate of 36.6% through 2030 [2]. This extensive growth highlights AI's broad integration across diverse sectors such as science, engineering, healthcare, automotive, and financial services. Accompanying this economic growth is a remarkable expansion in the AI job market, where it is projected that 97 million new jobs will be created globally by 2025, reflecting the increasing integration of AI across multiple business sectors [3]. In the U.S. alone, AI job vacancies have shown an annual growth of about 32% over the last few years, and median salaries for these positions have significantly exceeded the national average [4]. This trend underscores the lucrative opportunities within the sector and highlights the growing necessity for a skilled AI workforce.

Within the institution, the university strategic plan calls for increasing the institution's land-grant impact in aid of economic development and innovation in research and creative scholarship, with an eye towards growing the workforce, helping businesses within the state, and providing a superior education to students. Concurrently, Provost initiatives have included a strong emphasis on future-preparing graduates, including preparing graduates to lead in AI-forward work environments in industry, as well as focusing on interdisciplinary innovation. Given industry and institutional trends and needs, it is clear to the College of Engineering (COE) that an AIE degree is in clear alignment with the central university vision to prepare the engineering workforce in a computational world.

The body of knowledge and skills required to design, develop, and evaluate computation systems using AI technology requires a distinct set of courses from multiple disciplines. The Computing Research Association's annual Taulbee survey noted that "artificial intelligence (AI) and machine learning are the most popular Ph.D. specialties among graduates in the computer science, computer engineering and information fields" [5]. This interest at the graduate level has begun to filter down to the undergraduate level as seen by the development of AI baccalaureate degrees at several institutions nationally.

As of Spring 2025, there are a relatively small number of colleges or universities that offered undergraduate degrees in AI, including both Bachelor of Science and Bachelor of Arts degrees. Educational institutions are essential in equipping students with the necessary AI competencies to prepare them for diverse roles. These are not only positions within traditional technology industries, but also across sectors like public policy, where AI can aid in the analysis and implementation of volumes of complex legislative measures to supporting evidence-based policymaking, and in healthcare, where AI applications are accelerating drug discovery, revolutionizing treatment plans, enhancing surgical precision with robotics, and operational efficiencies. The broad demand for versatile AI skills highlights the importance of AI education in cultivating a workforce capable of integrating AI into various domains effectively and ethically. Given the noteworthy market growth and the broad range of job opportunities that span beyond the AI sector into social, medical, economic, and environmental fields, there is a compelling need for AI degree programs starting at the undergraduate level and leading to the graduate level.

Collaboration with Industry

Increasingly, AI is made more accessible for all and is becoming central to many organizations, through technologies such as cloud platforms for AI services, conversational AI, augmented intelligence, chatbots, machine learning, and other intelligent applications that embed AI within other offerings from enterprise resource planning to customer relationship management, human capital, and workforce productivity management. Several 2023 Gartner surveys found that 55% of organizations are in piloting or production mode with generative AI, 39% of organizations currently use AI in the finance function, and more than half of organizations that have previously deployed AI always consider AI for every new use case that they are evaluating [6] – [8]. Wide and rapid adoption of AI technologies by organizations drives AI skilled job demand far beyond the current supply of qualified candidates. The demand for AI fluency—the ability to use and manage AI tools—has grown sevenfold in two years, faster than any other skill in US job postings [9]. Few industries stand out as much as artificial intelligence when considering future job opportunities.

A traditional approach to looking for job postings requiring a baccalaureate degree in AI is not presently meaningful due to the limited number of such degrees. However, developing an AI degree to meet workforce demand and partnering with industry to determine their needs are essential in the evolving field of AI.

The Penn State University School of Electrical Engineering and Computer Science (EECS) sought input from its industrial advisory board members. Over a five-year span of engagement, the industrial advisory board became more interested in a new AI degree that had the same rigor as the school's computer science degree. In 2019, the board had believed that a computer science degree with some exposure to AI and Machine Learning (ML) was sufficient. By 2023, the board felt an AI minor was needed. By 2024, the same group insisted that graduates had a deeply technical degree on par with computer science or engineering and recommended topics in computer science, computer engineering, and electrical engineering The group included members with experience at Google, Nvidia, LinkedIn, GE Healthcare, and Dell. Some of their comments and recommendations were:

- There is a need for forward looking AI-optimized microprocessor/semiconductor content to prepare Electrical Engineering (EE) / Computer Engineering (CMPEN) students to develop (for example) tomorrow's version of NVIDIA's Blackwell GPU (a CHIPS Act opportunity).
- There is a need for forward-looking AI technology development content to prepare Computer Science (CS) students to develop future AI tools such as tomorrow's Google TensorFlow (or Amazon's SageMaker) or OpenAI's GPT.
- There is a need for AI skills such ML/AI algorithms, network models, vision and language modeling, generative AI, deep learning Libraries, AI frameworks, and so on; there is a need for engineers to have strong CS/CMPEN/EE skills across various roles in the AI ecosystem.

Industry partners also demanded interdisciplinary AI professionals who integrate technical, business, domain, and customer-centered competencies with understanding of social responsibility and ethical implications of AI technologies. Many of the industry partners expressed that they needed "critical thinkers, not passive users." This demand exists at the baccalaureate level for entry-level positions poised to have immediate organizational value and impact. While academic institutions continue to make valuable contributions to AI research, industry has emerged as a significant driver of practical AI innovation.

This paper focuses on two research questions:

1. How can the institution support industry with highly talented technical undergraduates with AI skills?
2. What can the institution learn about developing a degree program in a rapidly evolving field?

Theoretical Premise and Research Methods

The research described in this study is qualitative in nature. As noted by Creswell and Poth [10], "qualitative research [is used] to develop theories when partial or inadequate theories exist" and when "existing theories do not adequately capture the complexity of the [research] problem." The value of entering a qualitative study with a pre-conceived theory is contested in the qualitative methodology literature – for example, Garvey and Jones [11] cautioned that "the use of a theoretical framework in qualitative inquiry has the potential to bias findings or stifle inductive." In view of that, the researchers entered this work principally looking for the work to inform the researcher's theoretical views. As a starting point, Macpherson [12] calls for contextualized and integrated approaches to curricular design guided research focus, particularly for multi-way partnerships between stakeholders such as faculty, industry, and society. Such an approach is not new to engineering curriculum research; contemporaneously to Macpherson's paper, Sottile, Mohan, and Barber [13] demonstrated the utility of faculty-student-industry partnerships for engineering curricular design with a focus on engineering students' professional skills development in a similar institutional context as the subject institution, finding that the approach itself also provided unique learning and collaboration opportunity for the involved participants (e.g., students and faculty).

Similarly, the qualitative methodologist Joseph Maxwell [14] has called for qualitative research approaches that involve the research "construct[ing] and reconstruct[ing one's] research design" that avoids "begin[ning] from a predetermined starting point or proceed[ing] through a fixed sequence of steps." To allow such flexibility, this research inquiry was centered on memoing, where "the researcher creates, defines, and refines conceptual categories [and] makes tentative notes about links between concepts" [15]. Consistent with Creswell and Poth's [10] call for qualitative research work to be validated by multiple approaches, this qualitative study is informed by both the triangulation of data sources (i.e., by collecting, reviewing, and comparing multiple data sources) and by member checking (i.e., engaging with participants throughout the study to share data and evolving findings), discussed by Miles & Huberman [16].

The Program

Due to the rapid interest in a new AI degree and the emerging context, vocabulary, and interdisciplinary nature of AI, the department decided to develop a fairly dynamic curriculum to accommodate and embrace advancements. The administration envisioned all students to be grounded in AI literacy through experiential learning, enabling students to learn AI concepts by using, testing, and evaluating real tools and systems. This baccalaureate AIE degree program is designed to share a common set of courses with another college within the institution, [information science college]. To provide a comprehensive and flexible approach to AI education, the AIE major is structured in three tiers. The foundation is built on core courses, providing essential skills for all AI students covering essential topics such as programming, discrete mathematics, artificial intelligence basics, mathematics, probability and statistics, algorithms, machine learning, and responsible AI. Alongside these AI-focused core courses are courses covering engineering-supporting topics in science, math, and communication as well as courses specific to the AIE degree that provide greater depth in the subject: optimization for ML, deep learning, AI systems and tools, and a capstone design project. Building on these core courses are 27 flexible credits in technical electives, allowing students to tailor their learning path to their interests. Additionally, the department consolidated preparatory mathematics and statistics courses into a single course by prioritizing context and adding computational aspects to the course. Three new courses that were developed include: algorithmic tools in ML, optimization for ML, and AI systems and tools. Figure 1 illustrates this tiered curriculum model. General course subjects are listed rather than specific course names [for blind review] to illustrate the flexibility and progression through the curriculum.

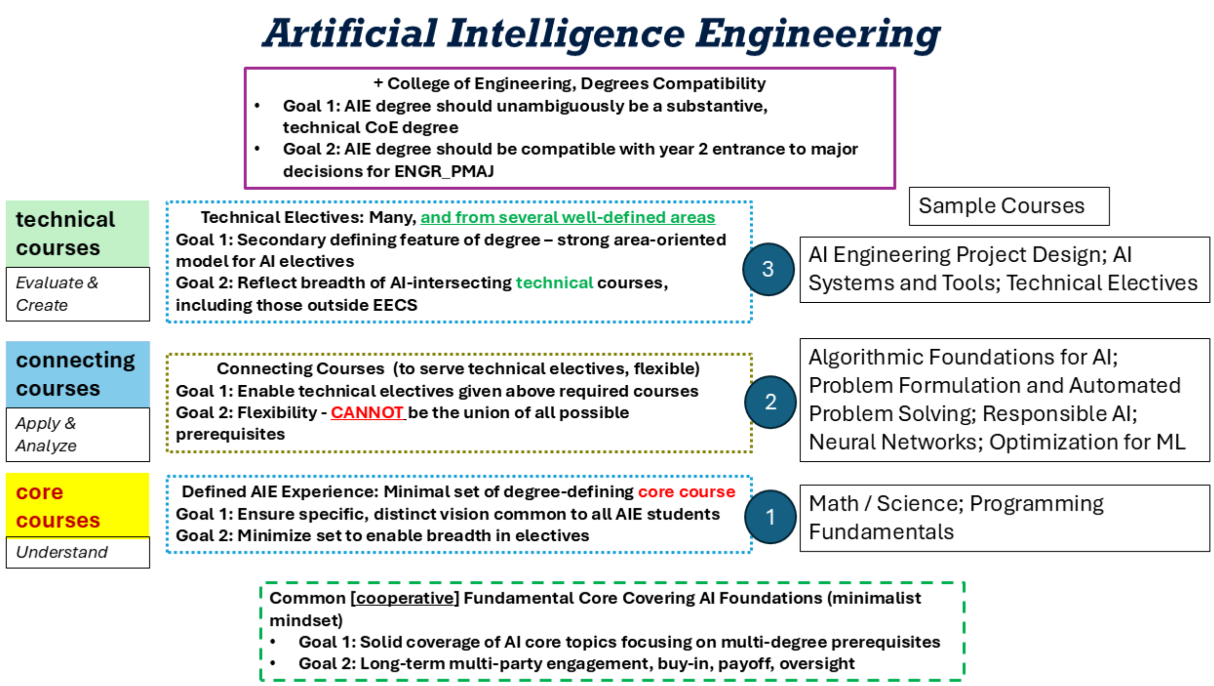

Figure 1: Three-tiered AI Engineering Curriculum

This adaptable model also facilitates the integration of new courses or focus areas as the field of AI evolves by adding appropriate elective courses and any necessary prerequisites. The technical elective courses are grouped into various focus areas including foundations of ML, robotics and computer vision, natural language processing (NLP), hardware systems for AI, applications, etc., enabling students to choose technical electives based on their interests and career goals and specialize in their preferred subfields of AI. This structure ensures a solid grounding in AI fundamentals while offering the flexibility to pursue specialized knowledge, adapt to emerging trends in AI, and create personalized learning experiences. The overall program is flexible to add new elective areas in the future, and the common set of core courses provides the foundation to develop any other new AI programs across the institution.

The AIE program overlaps with the existing Computer Science (CS), Data Science (DS), and Electrical Engineering (EE) baccalaureate degree programs, as the AIE degree draws from each of these programs, since the field of AI contains elements of each. We expect [blinded] College of Engineering (COE) students who might be considering any of the existing degrees will also consider the AIE degree. Many courses in the AIE curriculum employ problem-based learning to engage students in real-world challenges, requiring them to apply what they learned.

We are able to use many of the same courses in the School for the first two years. Thus, while there will be some extra courses in introductory AI, the number of courses will not be as large as a new major introducing all new courses for its requirements. The degree will provide flexibility for students to keep on track throughout their studies, with options to seamlessly take courses or semesters at other campuses throughout the geographically distributed University. Campuses and colleges outside of the main campus will contribute to the degree by meeting the social mobility-driven organizational structure of the University and, where appropriate, providing access to all four years of the AIE curriculum.

Each course has been developed for the AIE degree, and the Program Learning Objectives are in Table 1. As part of an institutional initiative, all new course objectives and program learning objectives were peer-reviewed by the institution's [Center for Teaching Excellence] to ensure they are worded in Bloom's Taxonomy. The program learning objectives listed in the table incorporated the industry advisory board's comments on what they needed new employees to do. Building on best practices in curricular design, from the program learning objectives new courses and prerequisite courses were developed where needed to meet these objectives. Assessment of the courses and program follows the same processes as other courses and programs in the college.

To be eligible for entrance to this major, students must satisfy the following requirements:

- Have completed five specified entrance to major (ETM) courses with a grade of C or better in each course prior to enrolling in the degree program.
- Have achieved a minimum grade point average (GPA) of 2.60 prior to and through the end of the semester during which the ETM is requested.

The AIE ETM requirements are aligned with other COE program ETM requirements. A recent analysis correlated the courses and minimum GPA to retention and degree completion success.

Table 1: AI Engineering Program Learning Objectives

1. Students will analyze complex problems and identify where AI-based approaches offer an effective and acceptable solution by applying the principles of computing and other relevant disciplines.
2. Students will recognize the professional engineering responsibilities related to the design and use of artificial intelligence products, systems, and tools and will demonstrate their ability to make informed judgments relating to the associated legal and ethical principles in AI tools they have designed and used.
3. Students will apply theoretical foundations from computer science, machine learning, mathematics, statistics, and electrical engineering to design and implement computing-based solutions to artificial intelligence problems.
4. Students will formally analyze the performance and output of AI solutions and iteratively refine them to improve efficiency and quality.
5. Given the combination of a stakeholder problem statement and a set of ethical and computing requirements that are amenable to an AI-based solution, students will be able to design, implement, and evaluate an end-to-end solution, incorporating one or more artificial intelligence-based approaches, that meets said requirements.
6. Students will be able to use multiple modalities to communicate technical topics in AI, effectively, across a variety of professional contexts including both engineers and non-experts.

Since AI is a new and evolving discipline, the disciplinary accreditor ABET has not yet published any criteria or guidelines for AI programs. An ABET evaluator in a recent ABET reaccreditation visit for another program stated that AI criteria are forthcoming. The new AIE program will seek ABET accreditation, like all other engineering and CS programs at the institution. The AIE program employs the same institution assessment systems as the CS program, so that they can map ABET student outcomes when accreditation is possible.

Other Resources

The partner colleges and campuses of the degree program agreed to contribute faculty and instructional resources. In addition to existing EECS faculty, we anticipate the AIE degree will eventually require four new personnel additions to support the AIE program.

Students pursuing the baccalaureate AIE degree have the full suite of support offered by the COE, including the COE advising center (for students in pre-major status) and an assigned academic advisor (for students admitted to the major). AIE students have access to the COE career services office, including access to recruiting events, résumé preparation, and peer counseling. AIE students have access to the resources of the School of EECS, including outreach, alumni relations, and mentoring.

Currently, 20 students are enrolled in the major, and the window for new students to declare their majors after meeting the ETM requirements opened in Spring 2026. The Spring 2026 enrollment in the introductory AI course for the AIE program is 106, reinforcing anticipated strong interest in the AIE degree program. While the Fall 2026 admission cycle is underway, current interest in the AIE degree align with projections showing 240 students admitted to the AIE degree for the fall, with 13 students who have paid their admissions deposit at this point in the admissions cycle. It should be noted that these admissions and acceptance numbers are greater than those seen for some of the existing traditional COE baccalaureate engineering programs. Based on historical trends, these early numbers for the Fall 2026 admissions class suggest that this probably will be well enrolled. However, it should be noted there will be a “melt” period and some refinement as students narrow their preferred major, as is typical in all COE baccalaureate degree programs at Penn State.

Lessons Learned and Knowledge Generalizability

The previous sections provide the approach and evidence to answer the first research question. First, through an integrated approach with the school’s industry advisory board and faculty expertise in several departments, Penn State developed an attractive, new AI degree that is highly desired by well-recognized industry partners and appeals to undergraduate students. Providing authentic project-based learning and connecting that work to preparing program graduates for roles with industry needs is significantly rewarding. The scaffolding of core courses to connecting courses that prepare students for their technical electives and design projects allows them to ultimately pursue areas of interest for them or areas that might be articulated by potential employers, with continuing attention on AIE students’ professional skills development.

Second, the School learned many lessons from developing this degree program. Many uncertainties exist due to the new and evolving nature of AI, lack of accepted student outcomes, prescribed by ABET, and uncertainties in potential program growth and institutional support for scaling. Some of the salient lessons learned are presented below.

1. Stakeholder engagement – While academic institutions continue to make valuable contributions to AI research, industry has emerged as a significant driver of practical AI innovation. To ensure that undergraduate students are sufficiently prepared for employment in the AI economy, early and continuous engagement with industry partners is important to incorporate the evolving skills and knowledge desired by potential employers.
2. Emerging Discipline – The field of AI is advancing rapidly, making a static degree program design inherently ineffective. As a discipline, artificial intelligence engineering education needs a dynamic curriculum to accommodate and embrace advancements.
3. Accreditation – Although AI criteria does not exist at ABET, developing and aligning a new AI degree with the same rigor and outcomes as a current ABET accredited degree provides a level of assurance to students, industry, and faculty that the new program will AIE program graduates equally marketable and employable as any other undergraduate student in the COE. Subject interviews have suggested that they do not feel the AIE baccalaureate program is being built and refined as students progress through the courses, leading to greater social acceptance for the AIE degree program. Other institutions

seeking to enter AIE education should similarly ensure that program participants feel adequately supported as they continue engineering the future of AIE education.

4. Scalability and Sustainability – Desired student outcomes across college and university may quickly become outdated and may not scale across larger institutional infrastructure, training, etc. By aligning AI initiatives broadly across the university's AI framework, the AIE program captures the breadth of AI-related needs across the organization, including emerging technology and needs. Additionally, AI interests and talents exist in other engineering departments. This is a potential pool of faculty who may be able to teach as the program scales up. As new AIE programs emerge across the organizational field, inter- and multi-disciplinary perspectives are important elements to include in the curricular model towards ensuring broad-based AIE program design and delivery.
5. AIE derivative programs such as minors – A one-size-fits-all AIE minor cannot serve the diverse needs, contexts, and futures of students across all the COE's disciplines. Developing an AIE Minor for other COE majors requires an in-depth review of specific courses and prerequisites in the minor. Different departments have different desired outcomes for different engineering majors in terms of technical depth. Other COE departments need to include discipline-specific electives in the minor. As AIE derivative programs emerge both at Penn State and nationally, early and continuous stakeholder engagement (just like industry partners) is essential.
6. Student involvement – Experiences from the development of this AIE baccalaureate curriculum highlight that many undergraduate students are early adopters of AI and bring valuable information and feedback from interviews and internships. Upon reflection, it became clear that the AIE curriculum developers missed opportunities to learn more about industry expectations and needs by not including students. Across the field, peer and potential peer programs will benefit from more robust undergraduate student participation in AIE program design decisions.

Future Work

Much of the future work for the AIE degree will center around keeping the student outcomes current and aligned with stakeholder expectations. Continuous and future work must focus on properly resourcing the operations of the degree program. This section presents the various inputs, methodology, and outcomes of modeling the expected fiscal impact of the baccalaureate AIE program for both the institution and its academic partners.

Students: We are expecting the total new enrollment to be 280 new students into the COE. The AIE enrollment could be higher, but some of the enrollments will come from the existing CS, CMPEN, DS, and/or EE degrees and possibly from other engineering disciplines. We have adopted a conservative outlook regarding student enrollment projections. We anticipate 30 students in year 1 and 50 students in year 2. Starting in academic year (AY) 2027–28, the program is expected to admit 100 new students each year, with the steady-state enrollment capped at 280 students. These numbers reflect new students to the college; enrollment may be higher due to attrition in other majors. This capacity is intentionally modeled conservatively; it is likely that actual enrollment will exceed this figure based on projected demand.

Faculty: In addition to many current CS, CMPEN, and EE courses, this new degree introduces 11 new courses at the start (AIE courses, AI courses, and one new mathematics course). Students will take 57 credits of coursework in the School of EECS. New faculty are needed to cover the number of new courses and course sections being added to the EECS curriculum, and to cover the increased teaching load in credit hours. The present Computer Science Department teaching load is already extremely high. The current tenure-track faculty in the department already teach an average of 76% more student credit hours (SCHs) than the COE average. Current department contingent faculty already teach 175% more student credit hours than the COE average. New faculty hires will occur over time and require the right blend of research and teaching skills to establish the new AIE degree. Managing these dynamics will require careful attention and central COE support.

Teaching Assistants (TAs): The average number of student credit hours per TA in the department is 11% more than the average in the COE. For now, the department requested only 10 new TAs at steady state for each year beginning in AY29. The first three TAs are expected to be onboarded in FY27, aligning with the early growth of the AIE student body.

Staff (Administrative and Operational Cost): Current School of EECS academic advisors serve 500 students each and currently advise four distinct majors (CS, CMPEN, DS, and EE). The department anticipates requiring at least one academic advisor for the additional 280 students anticipated in the new AIE major. Administrative and operational support will be provided by one full-time advisor, starting in the program's second year (FY27).

Minors in AI: The department has recently launched an AIE minor, intended for students in closely related disciplines such as CS, CMPEN, and EE. Given its relative newness, as well as late and little visibility to-date, the minor has soft launched; further, there is a characteristic of undergraduate students in the COE tending not to formally declare their minors until their graduating semester, so it will likely be a number of semesters until reliable enrollment trends become discernible for the AIE minor. Beyond an AIE minor, conversations are ongoing within the institution regarding an "AI for All" minor concept, with the intention of providing AI literacy and skills to those undergraduate students with a less technical background.

Acknowledgements

The AIE program acknowledges the collaboration between industry partners and the faculty in Penn State's School of Electrical Engineering and Computer Science to make this academic program and degree possible.

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