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A New "Age of Generative AI" Paradigm for the Development and Management of Curricula in Undergraduate Environmental Engineering Programs

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Introduction

In a short but remarkable introduction to a history of mathematics volume published in 1930, David Eugene Smith, a noted mathematics education innovator of the time [1], poetically observed that teaching methods and curricula in his field must be viewed as "a moving stream instead of a stagnant pool...a stream which nevertheless has often become so saturated with sediment as to unfit its waters for human adsorption; and a stream that needs constant filtering if it is to serve this latter purpose" [2]. Such a statement is as true for engineering education today as it was for mathematics nearly 100 years ago. Engineering curricula must fit the purpose of preparing the future engineer for the workforce using methods and tools translatable to contemporary requirements while resting securely on firm foundations supporting independent, individual, and field-specific design and problem-solving abilities.

Though academia has long been a driver of innovation, relative timelines of technological advancement (especially of computational tools) and programmatic decision cycles with their subsequent inertia in implementation across four-year degree programs create tension. On one hand, new computational tools offer efficiency in problem solving and perhaps open time to in-depth exploration of topics in lieu of supporting skill building. On the other hand, experienced academics recognize the value of the potentially replaced supporting skills and see risk in curtailing their impartation to the next generation of engineers. Adaptation of handheld calculators and acceptance of online integration platforms such as Wolfram's *Mathematica*© in their own times caused charged discussions in faculty lounges and curriculum development committees [3], [4]. This tension is healthy and for the most part has led to a balanced, satisfactory product appropriate for its time.

Measured change to curricula is further tempered by external organizations that help engineering departments benchmark each curriculum with other peer institutions and against recent feedback from industry. From the highest level, professional licensure and its supporting educational requirements anchor engineering curricula. The National Council of Examiners for Engineering and Surveying's (NCEES) Fundamentals of Engineering (FE) Exam is the gateway to the professional engineer licensing process and is geared towards undergraduates completing accredited programs [5]. The FE Environmental Exam consists of 15 sections covering supporting skills, including calculus, fluid mechanics, and thermodynamics, as well as environmental-specific topics such as biological wastewater processes, atmospheric modeling, and solid waste management.

Generative artificial intelligence (genAI) may change current curriculum development processes in a way other technological advances have not. Publicly accessible, native language processing genAI tools have expanded greatly since the release of OpenAI's ChatGPT in November 2022. The U.S. Government Accountability Office estimated for the U.S. Congress in June 2024 that more than 100 million people use genAI globally [6]. Another estimate goes as high as 500 million unique users globally in 209 of 218 countries with over three billion visits a month to online genAI tools [7]. A global survey of businesses conducted in 2024 revealed that the portion of organizations using AI increased from 20% to 72% since 2017 [8]. GenAI use has increased from 33% to 65% in businesses queried by the same survey since it became widely available in 2023 [8]. The adoption of genAI is progressing rapidly, and a desire to harness its potential in a variety of ways exists among engineering students [9]. Underlain by enormous data sets and computing power, genAI has or is expected to have large effects on knowledge-based work [10]. GenAI's continual fast development and adaptation [11] may get inside traditional curriculum development drivers' (e.g. NCEES and ABET) review cycles. In these cases, changes to ABET criteria may lessen educational valuation from the perspectives of students locked into a dated curricula and their future employers.

In this work, we posit that genAI will cause environmental engineering curricula to add, shift, or abandon topical priorities. More significantly, we compare the length of time for review cycles of curriculum development drivers to genAI development timeframes and engineering firm genAI adoption decision cycles. Lastly, we propose a responsive framework that can be adopted to keep program curricula relevant in the new age of genAI.

GenAI in undergraduate environmental engineering education: initial applications and facsimiles of rate of change of genAI

Presently, genAI augments the value of current courses included in undergraduate environmental engineering curriculum. Integration of genAI into environmental engineering education—and engineering education in general to this point—has primarily focused on enhancing student problem-solving skills and simplifying writing and presentation requirements [12] as users begin to understand the capabilities of this rapidly burgeoning technology. Undergraduate environmental engineering students leverage genAI to tackle engineering problem sets and projects by identifying relevant equations, creating preliminary designs, performing mathematical computations [9], [12], and generally streamlining their problem-solving processes and enhancing their analytical capabilities. GenAI serves as both a creative and analytical aid to student writing and presentation [10], [13], helps students frame arguments, provides relevant evidence, and enhances clarity [9]. GenAI-driven tools further assist in technical writing tasks, such as drafting project proposals, documenting project methodologies, and synthesizing data and findings into coherent reports and presentations [12].

The future integration of genAI into environmental engineering education is set to revolutionize learning experiences by introducing advanced, interactive tools that enhance comprehension of complex engineering concepts [14]. One significant advancement is the development of simulated customer bots [13], through which students can engage with virtual clients, receiving and responding to project requirements, design feedback, and real-world engineering challenges [14]. The creation of demonstrative risk, reactor, and flow regimen simulators will allow students to engage in realistic, dynamic modeling of environmental systems [15]. GenAI-powered simulators such as these will replicate real-world scenarios and systems, where students will be able to manipulate variables, assess outcomes, and visualize the effects of different interventions, providing them with deeper insights into system behaviors [16]. Another promising development is the introduction of genAI-based design and modeling partners [17] that assist students in generating and refining innovative solutions by providing real-time suggestions, identifying potential design flaws, and offering optimization strategies, generally guiding and supporting students throughout the design process from conceptualization to modeling [14]. While not inclusive of genAI's advancements in environmental engineering education, these examples are representative of the extreme speed with which genAI is revolutionizing the teacher-learner interface [9].

Furthermore, there may be a point when using genAI's tools becomes foundational in some core curriculum subject areas, superseding their traditional necessity. The American Society for Engineering Education (ASEE) already explicitly cites artificial intelligence proficiency as critical to the demonstration of technical knowledge within the field of engineering as part of its proposed Competency Taxonomy [18]. Though perhaps unimaginable in scope today, genAI may serve in the future as the pocket calculator did for routine mathematical processes in these superseded subject areas. In these cases, the time freed from teaching traditional subject areas in depth may shift to students learning to partner with genAI in these fields. Instruction may then focus on prompt engineering [16] and extend to more advanced topics within that subject area.

As a tempering note, in clinical diagnoses, humans provided incorrect information 1.4% of the time, and genAI tools provided incorrect information 16.1-18.7% of the time [19]. However, this spread is being addressed as genAI progresses. Hallucination rates between OpenAI's GPT-3.5 and GPT-4 reportedly reduced by 11% [20].

The acceleration of genAI development, user saturation, and use intensity are hard to measure, especially at the bow wave of the technology's implementation. From 2010 to 2014, the growth of genAI related patents was 56.1% with less than 4,000 patents issued in 2014. Between 2021 and 2022, the number of patents grew exponentially by 62.7% with approximately 6,226,000 patents granted globally *[21]*. In U.S. businesses, genAI adoption has been uneven with most use happening in urban centers with bigger enterprises (>5,000 employees) or with younger founders *[22]*. Globally, as of March 2024, 82.2% of all traffic to online genAI tools has been to Open AI's ChatGPT. Because of this domination, we are adopting the timeline of its development as an indicator of the rate of genAI development. The average time elapsed between key events—major points of advancement in ChatGPT's capabilities—is 8.5 months (Table 1).

Table 1. Key Events and Time Elapsed in the Development of ChatGPT.

Key Event	Date of Occurrence	Time Elapsed
OpenAI is founded	December 2015	-
GPT-1 debuts	June 2018	30 months
GPT-2 debuts	February 2019	8 months
GPT-3.5 debuts	November 2022	22 months
ChatGPT Plus released	February 2023	3 months
GPT-4 released	March 2023	1 month
ChatGPT expansion with plug-ins and browsing interface	April 2023	1 month
ChatGPT mobile access enabled	May 2023	1 month
GPT-4o launched	May 2024	12 months

For context, ASEE's report highlighting the importance of emerging engineering technologies like genAI used data and workshop proceedings from May and October 2022 and was published in 2024 [18]. As reflected in Table 1, in the time it took to produce this report, the most prominent genAI platform, OpenAI's ChatGPT, underwent six major advancements. If averaged conservatively across even the earlier years of development, the ASEE report production timeline still covered an average of about three such key technological progression events. GenAI is developing at a rate that makes it difficult to even assess the impact of such tools within typical analytical time cycles.

GenAI in the practice of environmental engineering: applications and observed rates of change

Academia prepares students to enter the workforce. It should equip students to quickly understand current practices and prime them to share innovative approaches incubated at universities for their new employers to consider adopting. It is therefore necessary to examine how Architecture, Engineering, and Construction (AEC) firms are adopting artificial intelligence tools. Applications of genAI in the practice of engineering is a current point of research. Authors suggest that genAI may assist practitioners in activities as diverse as scheduling, hazard recognition, cost estimation, developing design specifications, infrastructure lifecycle management, and more [23], [24], [25]. Additionally, several recent studies provide insight into how genAI might be used to improve environmental engineering practices specifically. Zhang et al (2025) provided a helpful review of how genAI has been used in site layout design, interior design, and exterior design applications in built environments [26]. Sela et al (2024) discussed how genAI might improve water system operations [27]. Wu et al (2024) outlined how genAI could improve environmental engineering practices like treatment process design, environmental model development, and environmental policy evaluation [28].

However, very few published works report on the actual applications of genAI that environmental engineering firms have or are planning to adopt or of the rate at which these tools are being adopted. U.S. Census Bureau data from the 2018 Annual Business Survey identified the engineering-adjacent construction sector as notably lagging in AI adoption with only 4% of firms acknowledging its use [22]. Increased prevalence of genAI use surveys within the AEC industry and discussions at conferences surrounding genAI indicate that this technology's adoption has grown since 2018 [29][30].

To better understand how engineering firms are currently using and plan to implement genAI, we administered an eleven-question online anonymous survey and distributed it through professional networks such as the Society of American Military Engineers (SAME). The main goals of the survey were to ballpark AEC firm's decision cycle lengths regarding AI adoption and determine the past, current, and expected future use of genAI.

The survey was composed of multiple-choice questions, modified Likert scale questions, and free responses. Respondents practiced a diverse range of environmental engineering focus areas including hazardous waste management, water treatment and distribution, environmental restoration, and air pollution. Respondent's company sizes ranged from less than 50 to over 10,000 employees (median = 500). Comprehensive survey results are presented in Appendix 1.

Results show that the perceived/expected added value of genAI in engineering projects increased significantly from the past year with companies reporting genAI provided little net benefit to engineer projects (2.15) to expecting it to provide measurable benefits (4.25) more than a year from now. This result is validated by other, larger surveys. Polls from 2024 SAME Small Business Conference [30] and Deltek's 2023 45th Annual Architecture & Engineering Industry Study [29] show the number of AEC companies using genAI for some aspect of project management jumped from less than 50% in 2023 to almost 65% in 2024.

In the authors' survey, this trend towards greater acceptance of genAI also is reflected in the firms' responses regarding expected and preferred skills, certifications, and experiences relating to genAI for new junior hirers. Through analysis of open-ended question responses, 31.3% said they would *prefer basic knowledge* of genAI in new junior hires, 18.8% of companies expressed that they would *require basic knowledge* of genAI, and 25% said they would *prefer knowledge in effective use* of genAI coming into the job.

In trying to determine how genAI is being used, we asked firms if they currently use or plan to use genAI in the following categories: Prior Planning and Optimization; Consultation and Problem Solving; Project Management Monitoring; Engineering Design; No Use; or Other (with open response space to specify). Firms could choose multiple or none of the use categories. If a respondent indicated use or planned use of genAI in any one of our categories, that use was tallied to create the "Any GenAI Use" category in Figure 1. That accounting revealed that a majority of firms surveyed in this study use genAI in some way. Respondents currently use genAI predominately for consultation and problem-solving and project management monitoring (i.e. data analysis in both categories). Planned use increases were most prevalent for prior planning and optimization (e.g. creating proposals, summarizing documents, and value engineering) tasks.

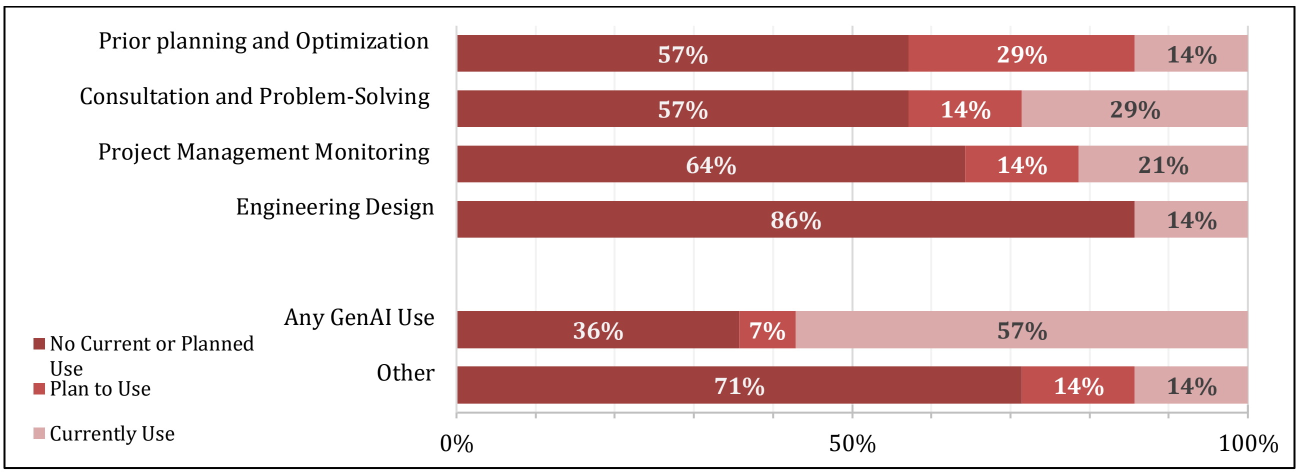

Figure 1. Results of how engineering companies are currently and planning to implement genAI throughout engineer projects.

Notably, firms seem to have an aversion to using genAI for engineering design purposes, which correlates with earlier studies' results. Deltek's 2023 study [29] and 2024 SAME poll [30] asked how AEC firms used genAI in binned categories generally aligned with our own. In these polls, genAI was used by less than 15% of respondents to complete more technical tasks such as developing 3D models, repetitive modeling tasks, design, and testing. Interestingly, the 2024 SAME poll showed decreased use of genAI for design-related categories compared with the Deltek poll from the previous year. This may in part be explained by concerns revealed in the 2024 SAME poll about employees' lack of understanding regarding genAI tools (43.8%) and associated security (i.e. confidentiality related to data breaches or external access to critical infrastructure data) concerns (18.8%). Similarly, respondents to the authors' survey identified a lack of familiarity with genAI's potential as a hurdle to adoption. Additionally, several respondents mentioned related concerns with quality assurance/quality control and liability.

When asked what they believe should be taught in an undergraduate program, most respondents promoted the nuanced use of genAI balanced with an understanding of its limitations and appropriate applications. However, firms were concerned that junior hires will not understand or know how to apply the critical engineering principles should students begin to over rely on genAI in their engineering course work. One survey respondent fears that there may be a "[l]oss of ability to critically review results from AI and inability to function without AI."

GenAI in undergraduate environmental engineering education: curriculum drivers and observed rates of change

Integration of genAI into professional engineering design work may continue to be slow, uneven, and non-transparent—even to engineering firms—as the modeling and design software they rely on integrate AI tools into their frameworks. Regardless, engineering programs' adoption of genAI will be accelerated or throttled by other drivers. The three main drivers of curriculum development at the authors' institution are ABET requirements, NCEES requirements, and internal review. A comparison of the driver review cycle lengths in relation to a genAI advancement cycle length can be seen in Figure 2.

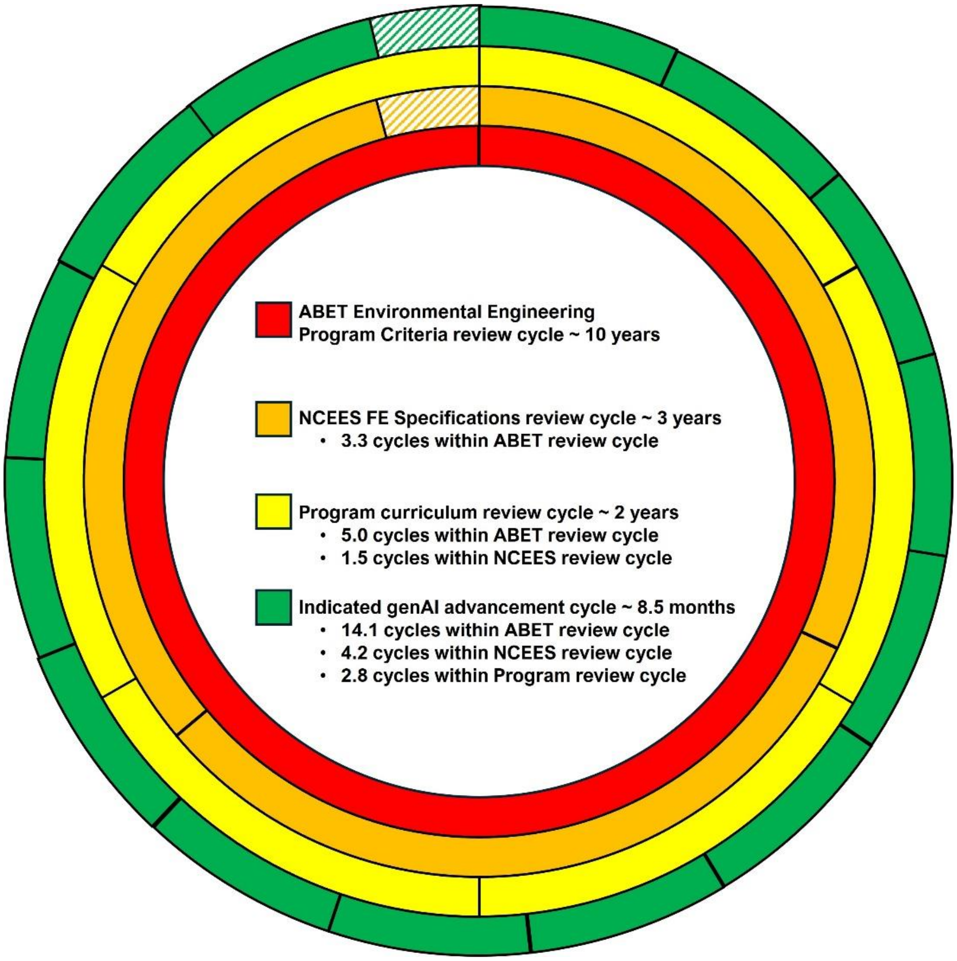

Figure 2. Comparative review cycles of curriculum development drivers in comparison to the genAI advancement cycle length as indicated by ChatGPT development. Segments of each concentric circle represent one complete review cycle of the associated driver.

Overview of ABET requirement reviews

Looking back over its ninety two-year history, it could be argued that ABET has made a limited number of substantive changes to its accreditation criteria chiefly due to the extensive quantity of stakeholders with a wide spectrum of opinions on what should change [31]. Further, accreditation requirements have steadily increased [32], [33] along with the burden on engineering programs [34]. The Environmental Engineering Program Criteria are developed by the American Academy of Environmental Engineers and Scientists (AAEES) and cooperating societies, which are then promulgated by ABET [35]. According to David Chin, president of AAEES, the Environmental Engineering Program Criteria are updated approximately every 10 years [36]. The Environmental Engineering Program Criteria have received substantive revisions only twice since 1997.

Overview of NCEES requirement reviews

Similar to ABET's long criteria review window, the NCEES typically reviews exam specifications for the FE approximately every six to eight years. Prior to updating exam specifications, NCEES gathers professional expertise and advice from licensed practitioners and educators to better define how the engineering profession and its respective disciplines are changing. This information enables NCEES to articulate those topics that will be more or less important for engineers at the time of their future licensure. In the past, the process from survey development to implementation of approved specification changes took approximately two and a half years. With the more recent advent of computer-based testing, this timeline may be shortened in future cases. Generally, numbers of questions by specification shifted slightly, with certain specifications increasing and others decreasing, while the naming convention of other areas were revised with no major content changes. Major changes included the addition of a new specification, Energy and Environment, that covers energy source concepts and environmental impacts of energy sources. Additionally, the Air Quality and Control specification was updated to cover indoor air quality.

Overview of the authors' internal curriculum review

Since Fall 2000, our Environmental Engineering Program has consulted with representatives of its constituencies outside of the institution and our faculty members, primarily via our Board of Advisors, to establish and review Program Educational Objectives. In general, the process is as follows: 1) Program Educational Objectives are reviewed and discussed by the Board of Advisors and selected program faculty members every year to ensure they remain consistent with our institutional mission, our program constituents' needs, and ABET Criteria. 2) Upon completion of the discussion, any recommended changes are discussed with all Environmental Engineering Program faculty members at the fall annual assessment briefing and subsequently staffed through the Environmental Engineering Curriculum Coordinator; the Environmental Program Director; and the Department Head. Additionally, minor changes (grammar, style, etc.) are coordinated via email, if necessary. 3) Upon concurrence, the Program Educational Objectives are updated, briefed to all Environmental Program Faculty and students prior to the effective academic year, and revised on our website and in official documents. This process is documented in our annual program assessment report. Input from all faculty members on curriculum issues, assessment and evaluation processes is also periodically obtained during the program assessment briefing, conducted in early fall each year.

Our program employs an assessment and evaluation process that systematically analyzes how well each course accomplishes course-level outcomes and ABET Student Outcomes annually. The goal of this process is to ensure that curriculum changes can be made to attain the Student Outcomes and that courses remain rigorous, relevant, and well-integrated in the program. Due to periodic faculty turnover, course assessment also serves as a means of maintaining course continuity. At the course-level, we assess course outcomes annually using a formal written assessment called a Course Assessment Report. Effective course assessment considers all relevant information to identify strengths and weaknesses in each course. Where appropriate, these areas for improvement are used as the basis for well-coordinated changes to course outcomes, course content, or course processes. Effective course assessment is an inclusive, collaborative process in which all relevant stakeholders—including instructors, course directors, the environmental engineering curriculum coordinator, and the program director—are given the opportunity to influence the future direction of the curriculum.

Incorporation of genAI features in undergraduate environmental engineering curriculum

Hargroves and Desha provide a curriculum renewal framework that might be leveraged during a genAI-focused reformation of engineering education [37]. Hargroves and Desha's framework is a five-step process that occurs iteratively. Within this framework, engineering programs identify sustainability-focused desired graduate attributes, craft learning pathways to produce them, develop methods to audit those desired outcomes, and then update curricula and implement programs to produce graduates with desired skillsets. Such a process can be remolded to address genAI-focused skills development and evaluation.

The first step (Identify Graduate Attributes) can be implemented easily using existing Student Outcomes with one modification. Programs should adopt one further attribute dynamically related to genAI literacy. As Hagroves and Desha write, this calls for an active faculty that stays current with the state of the science and practice through professional organization membership, conference attendance, and continuing education [37].

External to the program, we advocate for the regular collection of survey data from industry partners. We suggest that NCEES incorporate our genAI related questions (or similar ones) into its regular practice of surveying its established network of engineering firms. Resultant data would augment academic curricula innovations with insights into practical applications of AI-related skills as well as potential future FE exam formulations. Since the NCEES cycle length nearly matches that of the engineering program curriculum review cycle, those results should be easily integrated into academic processes. However, as the percentage of firms using genAI climbs above 30%, a current benchmark where genAI appears to be transformative for industries such as healthcare [22] and is supported by Rogers' diffusion of innovation theory [38], we suggest that NCEES deploy the genAI survey annually and make the results publicly available to allow improved programmatic tracking of genAI adoption rates.

As a variation, NCEES could simultaneously survey engineering programs and practitioners about their use of genAI and assess what material (if any) should be added or deleted from exams. NCEES also could provide engineering program data to engineering firms to spark innovation ahead of the capillary action of knowledge brought by junior hires gaining seniority over time.

The streamlining of communication between industry and academia through NCEES may in turn persuade ABET to shorten its review cycles for the Program Criteria and Student Outcomes. The optimization of communication and review processes at scale across academia and professional engineering organizations may subsequently result in the modernization of state licensing systems to account for genAI effects. Key to the success of that structural reformation is the continuance of the ABET emphasis on Student Outcomes over curriculum criteria, as begun in 2000 [31], [39]. Such emphases will free engineering programs to innovate and remain current in the genAI age.

In Hargroves and Desha's second step [37], programs should continue to map learning pathways, a process already done during curriculum reviews, with genAI in mind. Programs can include introductory course blocks of instruction in genAI literacy and continue to develop the AI use concepts through the curriculum in a fashion similar to fundamental environmental engineering principles like mass balance. We promote the concept of genAI prompt engineering proficiency as laid out by Samsami (2024), which also discusses risk management of the incorporation of genAI in engineering [23]. Though not an exhaustive list, other suggested threads for pathways and points of insertion in environmental engineering courses internal to the engineering program are presented in Table 2.

Table 2. Suggested threads with which to build relevant, genAI inclusive learning pathways; includes some appropriate generic course titles for locations of curriculum integration **[40]**.

Suggested Thread	Some Learning Pathway Inclusive Course Titles
Prompt Engineering and Human-AI Collaboration	Intro to Environmental Engineering Data Science for Env Engineers AI Ethics & Environmental Policy Capstone Design Project
Data Literacy and Computational Thinking	Data Science for Env Engineers Intro to Programming Statistics & Uncertainty
Algorithmic Thinking and Machine Learning	Data Science for Env Engineers Capstone Design Project
Modeling and Simulation Skills	Fluid Mechanics Water/Wastewater Treatment Hydrology & Watershed Modeling
Spatial Reasoning and GIS-AI Fusion	GIS & Remote Sensing Solid Waste Management Hydrology
Sensor Networks and Smart Infrastructure	Fluid Mechanics Lab GIS & Remote Sensing Capstone Design Project
Team-Based AI Project Skills	Capstone Design Project Any lab-based course or semester project
AI Ethics, Regulation, and Transparency	Intro to Environmental Engineering AI Ethics & Environmental Policy Capstone Design

A layout of these environmental engineering courses over four years may follow something similar to Table 3.

Table 3. A proposed layout of environmental engineering courses with suggested applications enhancing AI literacy [40].

Year	Course	Applications for AI Integration
Freshman	Introduction to Environmental Engineering	Overview of AI in environmental systems; ethical and societal context
Freshman	Calculus I & II	Foundation for modeling and numerical methods
Freshman	General Chemistry + Lab	Chemical data handling; basic reaction modeling
Freshman	Introduction to Programming	Data structures, scripting, basic analysis
Sophomore	Fluid Mechanics + Lab	Flow simulation and digital twin concepts
Sophomore	Environmental Chemistry	Chemical speciation modeling with data tools
Sophomore	Data Science for Environmental Engineers	Intro to machine learning (ML), sensors, time-series analysis
Sophomore	Statistics & Uncertainty Analysis	Regression, error propagation, model evaluation
Junior	Water and Wastewater Treatment	Process design and AI-driven control systems
Junior	Hydrology and Watershed Modeling	ML-enhanced runoff prediction and climate impacts
Junior	Air Quality Engineering	Sensor networks, real-time modeling, emissions forecasting
Junior	GIS and Remote Sensing for Environmental Design	Use of AI in spatial pattern recognition and risk mapping
Senior	Environmental Microbiology	Genomic data and microbial community modeling
Senior	Solid and Hazardous Waste Management	Landfill monitoring, gas flux prediction using AI
Senior	AI Ethics and Environmental Policy	Bias, transparency, and policy implications of AI tools
Senior	Capstone Design Project	Multidisciplinary team project using AI-enhanced modeling, sensors, and design optimization

Concurrently, engineering programs can audit learning outcomes, the third step of curriculum renewal, for programmatic inclusion of genAI in a way that the learning pathways are supported and not duplicated or left absent. This portion of the curriculum renewal process can be informed by the proposed NCEES engineering firm survey. We suggest that the 30% saturation benchmark for genAI use in environmental engineering focus area applications be adopted as a limit which, once surpassed, then requires genAI incorporation into topical environmental engineering education. If >30% of AEC firms begin using genAI for foundational engineering tasks, then engineering programs should accordingly incorporate industry practices into innovative modifications of educational learning pathways.

Academic programs can then work within existing curriculum coordination committees to ensure strategic embedding of learning pathways across holistic academic programs. Learning pathways could be revised as necessary. During this process, programs can look for new areas of collaboration across the academic institution and within the community. If surveys indicate significant adoption of genAI tools by industry (>30%) for certain applications, engineering programs should look toward reformation of their course designs. For instance, if genAI is broadly adopted for reactor design or fluids modeling, programs should look across departments to build courses that are centered around use of those tools with emphasis on environmental engineering topics that may be independent of media or treatment trains. Existing in-depth subject matter displaced by genAI course objectives could instead by replaced by more cursory systems overviews in introductory classes and reviewed in capstone design courses. Further, programs could improve proactive innovation by adopting a response framework like what we suggest in Table 4. Programs could track genAI adoption rates by focus area if provided access to publicly available survey results. An ABET or NCEES survey like the one proposed in this manuscript could furnish those data. Access to such information may help temper disruption from technological changes to engineering curricula and thereby prevent revolutionary upheaval caused by slow reactions to change.

Table 4. Suggested industry-adoption thresholds which could trigger responses by academia to modify existing engineering curricula. Adoption descriptions were developed in part from Rogers (2003) [38].

Industry Adoption Rate (%)	Industry Adoption Description	Curriculum Response Examples
< 20	Innovative	Offer optional seminars
20 – 30	Early	Create capstone projects; incorporate software tools
30 – 40	Significant	Update core course objectives and labs; add an elective
40 – 50	Majority	Require genAI-related design projects; offer a minor
> 50	Established	Offer dedicated core courses; assess accreditation changes

We encourage engineering programs in academia to operate with a clear, broad understanding of how and where the genAI-enabled learning pathways intersect with student development as they work to implement curricula. They should monitor course assessments closely and identify prudent changes. Longitudinal performance metrics like running averages of FE exam performance could be used to assess balance within their programs and diagnose systemic problems with programmatic changes. A strong network of communication between academia, industry, and accrediting bodies could then help to fine-tune the overall system to ultimately yield competent professionals able to think critically and apply foundational engineering knowledge in a complex world. The potential for a reformed, effective profession amidst an AI revolution exists. We encourage decision-makers toward that reform and the provision of critical data to make it possible.

Conclusions

Processes exist for the evaluation of engineering program accreditation criteria and for modification of professional examinations, but the rapidity with which the genAI technological innovations are progressing demands more frequent (at least once per academic year given genAI's indicated rapid rate of change) and time-efficient review cycles. Academia necessarily holds responsibility for the updates and implementation of engineering curricula, but success in the remaining components of a curriculum renewal process depends on cooperation between industry, accrediting agencies, state governance, and academic institutions. We propose that, in a digital age, communication between industry and academia should be streamlined and engineering programs be permitted by accrediting agencies to build timely, responsive curricula for the competent, responsible, ethical, and critical employment of genAI by graduates in the practice of engineering.

Disclosure of the Use of AI

The authors iteratively used ChatGPT to suggest areas or topics ripe for AI integration within typical undergraduate environmental engineering curricula [40].

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Appendix 1: Survey Data

To better understand how engineering firms are currently using and plan to implement genAI, we administered an eleven-question online anonymous survey and distributed it through professional networks such as the Society of American Military Engineers (SAME). The main goals of the survey were to ballpark AEC firm's decision cycle lengths regarding AI adoption and determine the past, current, and expected future use of genAI. We furthermore asked for defining demographic data, such as firm size (employment number). The survey was composed of multiple-choice questions, modified Likert scale questions, and free responses.

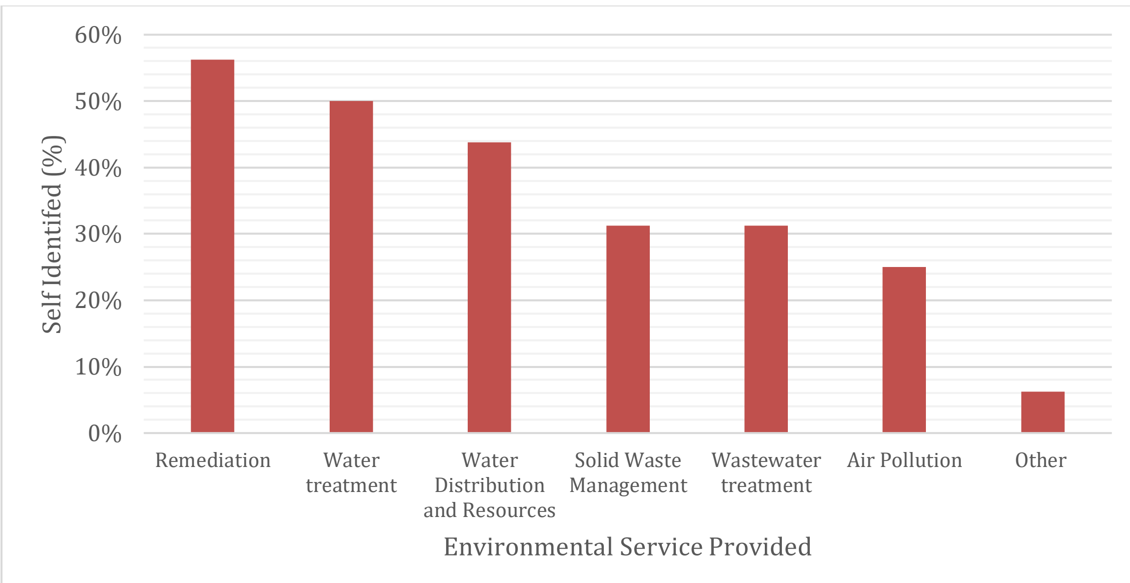

Figure 1.1. Firms self-identified services provided from a given list. The respondents were able to select multiple categories. The one "Other" response was "DoD Environmental Program Management." (n=16)

Appendix 1: Survey Data

Table 1.1a. This table outlines current and expected future use of genAI. Respondents selected from a provided list and could select multiple uses. They were provided an "Other" option where respondents could give an explanation. (n=14)

Current Use of GenAI
No current uses, Other: Current moratorium in using ChatGPT, Bard, etc.
Engineering Design, Consultation and Problem-Solving Response
No current uses
No current uses
Project Management: planning and optimization (prior), Project Management: monitoring (during), Consultation and Problem-Solving Response
No current uses
Other: report writing
Consultation and Problem-Solving Response
Engineering Design
No current uses
No current uses
Other: proposal responses
Project Management: monitoring (during), Consultation and Problem-Solving Response, Other: Routine reporting
Project Management: planning and optimization (prior), Project Management: monitoring (during)
Expected Future Use of GenAI
Project Management: planning and optimization (prior), Project Management: monitoring (during), Other: New ERP platform (Oracle)with some AI capabilities
Project Management: planning and optimization (prior), Engineering Design, Consultation and Problem-Solving Response
No planned uses
No planned uses
Project Management: planning and optimization (prior), Project Management: monitoring (during), Consultation and Problem-Solving Response
No planned uses
No planned uses
Consultation and Problem-Solving Response, Other: Screening scenarios to match through applicable regulatory frameworks
Project Management: planning and optimization (prior), Project Management: monitoring (during), Engineering Design, Consultation and Problem-Solving Response
No planned uses
No planned uses
No planned uses
Project Management: planning and optimization (prior), Project Management: monitoring (during), Consultation and Problem-Solving Response, Other: Routine reporting and completion reports
Consultation and Problem-Solving Response

Appendix 1: Survey Data

Figure 1.2. Firms self-identified size based on number employees from a given dropdown list. (n=16).

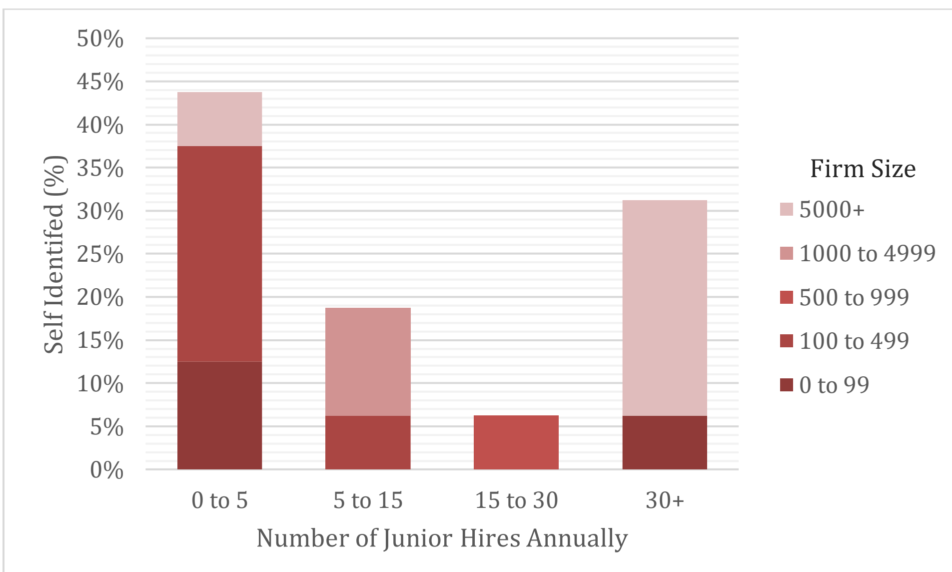

Figure 1.3. Firms self-identified number of junior hires per year from a given dropdown list. (n=16). Firms with 20 to 49 employees are most frequently hiring 0 to 5 junior engineers each year.

Appendix 1: Survey Data

Table 1.1b. This table describes how values were binned according to responses. There was a trend with a few respondents of only selecting an option for "Current (but not future)". It is assumed that they will continue to use genAI in the future in the same manner as the present.

Category of Use	Current (but not future)	Current and Future	Expected to in Future	Will Never Use
(1) Prior planning and Optimization	1	1	4	8
(2) Consultation and Problem-Solving	0	4	2	8
(3) Project Management Monitoring	2	1	2	9
(4) Engineering Design	2	0	0	12
Any Use	2	6	1	5

Appendix 1: Survey Data

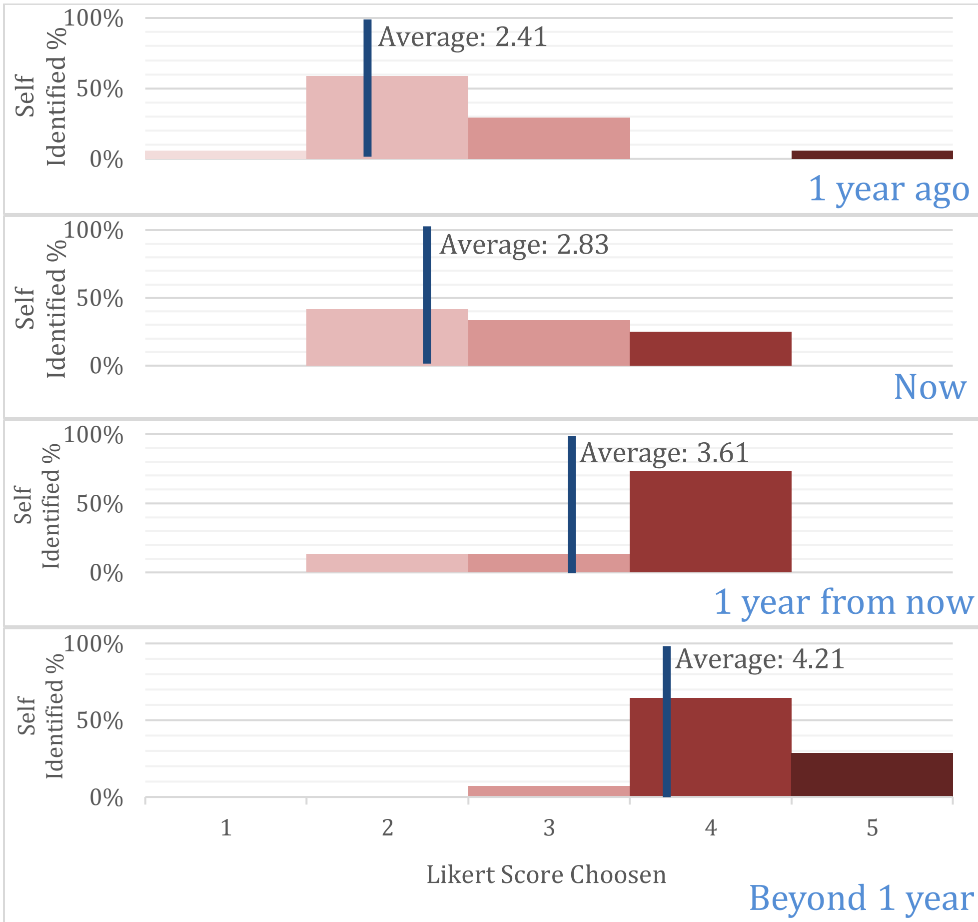

Figure 1.4. Respondents were asked how much added value did/does/will genAI provide to engineer projects on a Likert scale:

(1) Negative – AI detracts from projects and its use hampers success,

(2) None – AI is largely ineffective and yields little-to-no net benefits to projects,

(3) Limited – AI provides enables some discernable positive impacts to projects in low-impact areas,

(4) Moderate – AI provides measurable, significant benefits to projects, but its impact is not transformative, and

(5) Critical – AI plays a critical role in projects. Major aspects of projects, and some entire efforts, could not succeed without it.

Appendix 1: Survey Data

Table 1.2a. Respondents were asked in a free response question what skills, certifications, experiences relating to genAI they would require or prefer a new junior hire to have. (n=13)

Required **Skills, Certifications, & Experiences for New Junior Hires**
None at the moment.
None currently defined
Currently - none would be required, as it is not being used. It would be beneficial to have a basic understanding of it use and applications.
No skills, certifications, and experiences related to AI.
Knowledge of AI, benefits, and implementation.
None
None
None
Unknown
Don't know enough about AI to know what skills would be.
None
General ability to use AI to improve writing skills and ability to summarize data using AI
None
Preferred **Skills, Certifications, & Experiences for New Junior Hires**
Unsure as it's relatively new from the industry perspective.
Exposure to computer programming, statistics
Currently, a basic understanding is all that we would prefer. As AI is further developed and implemented, there may be more use or expectations for additional experience.
Zero. AI still requires several inputs to grow and learn. We are focused on letting other companies master AI, and presenting a finished product once it becomes easy to use.
Not yet familiar with certifications
None
None
Effective AI prompt writing and use as productivity enhancement tool.
Comm skills
Don't know enough about AI to know what skills would have to be.
None
Ability to train AI to conduct routine reporting and data evaluation tasks
Understanding of concepts and benefits/risks

Table 1.2b. This table describes how values were binned according to responses. For "Ability to be trained" that can be assumed to be basic knowledge. (n=13)

Knowledge Level	Required	Preferred
None	10	5
Basic	3	4
Effective Use	0	3
Ability to be Trained	0	1

Appendix 1: Survey Data

Table 1.3. List of respondent concerns regarding genAI use by new junior hires. This was an open-ended question (n=11).

Any other concerns with AI use by new junior hires?
There are some cybersecurity issues from a corporate perspective. Overall, there is some skepticism in that AI tools have or will replace actual aptitude, knowledge, and mastery of a specific subject matter.
Understanding the security behind the use of AI, especially as it applies to critical infrastructure.
If a student hire has experience with AI, then they have an ability to experiment with a new type of software. I would still hire students based on their engineering knowledge and critical thinking skills over letting the AI make critical decisions.
Some, AI can generate incorrect information and that can be a liability if not good QA/QC program
AI, at some point will be like using a calculator or computer. The most critical need in a new hire is the ability to learn new information and sound fundamental knowledge in engineering concepts.
if used, must be used ethically
Network security. Only enterprises authorized AI applications are allowed for use on company IT equipment or networks. So it is imperative that employees do not compromise enterprise network security using unauthorized AI applications.
Misuse in project context
Concerns with them using AI to write reports rather than actually understanding the data and formulating a thoughtful report to digest and disseminate the data
Loss of ability to critically review results from AI and inability to function without AI.
The junior hire would not have the skilled experience to qualify AI generated outcomes

Appendix 1: Survey Data

Table 1.4. List of recommendations by respondents for undergraduate engineering programs to ensure that they are preparing their graduates with sufficient genAI skills to enter the workforce. This was an open-ended question (n=11).

How can undergraduate engineering programs ensure that they are preparing their graduates with sufficient AI skills to enter the workforce?
Understanding AI as a tool to enhance productivity, not replace it. There should always be a human component to any AI-related process from a quality standpoint. Expect the workplace to embrace AI less than experienced in college with the understanding there's a lag of understanding and use. Be a champion of AI and show senior colleagues it's potential use in various activities. This innovation will drive the success of your personal career and the business overall.
Traditional engineering includes process laboratory work. Would be interesting to know how lab will morph to include AI, beyond what may be involved in a 4th-year engineering program's year-long group project.
At this time, programs that are able to provide graduates with an understanding of where and how AI can be used as well as the pros and cons of using AI would be sufficient. As with any new technology or application, we should be cautious that we do not lose sight of basic engineering principles and the understanding or comprehension of results provided by AI.
At this time, have students use AI to make decisions and calculations. Then add more human factors to demonstrate the pros and cons of relying solely on AI.
To start with just to know what AI can do, keep current, know how best to apply
Help students to have good fundamental understanding of technical concepts. Learning AI, if they are trained as good engineers, they will pick up the skills needed for AI.
cover ethical use
Use it to foster their critical thinking skills while still driving fundamental theoretical concepts such as ideal gas law, Bernoulli equation, Gaussian plume, Darcy’s law, etc. as well as making them work hard so that they know just how hard they can push themselves. This will allow them to have the work ethic required to get results in the professional workplace as well as innovate to work smarter and thus drive continuous improvement.
Use in context that it is a tool and does not replace human engineering judgment.
Teaching them that AI is not a stand-alone solution, and any AI-produced product needs to be heavily scrutinized/checked for QA/QC and make sure it makes sense.
Provide class(es) in training AI to specific projects as well as tools to evaluate results from AI