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Artificial Intelligence (AI) Usage in an Undergraduate Chemical Engineering Course: Strengths, Pitfalls, and Future Insights

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ABSTRACT

As Industry 5.0 (I.D. 5.0) reshapes the engineering education landscape, Higher Education Institutes (HEIs) have evolved to integrate Generative Artificial Intelligence (GenAI) via strategic curriculum revamps to meet Education 5.0 (E.D. 5.0) competencies. EN.540.202 (Introduction to Chemical & Biological Process Analysis) is the first core course at Johns Hopkins University and was revamped in Fall 2025 to create more rigorous course content and the conscious creation of new weekly graded problem sets, which did not rely on prior course content/textbook-based solved examples. Problem sets were fed as Effective Prompt Engineering (EPE) inspired prompts to ChatGPT, and AI-elicited responses were compared. AI was able to perform fundamental calculations, offer detailed explanations, unit conversions/checks, proactive information (outside the problem scope), and graphical information. Key challenges and pitfalls observed were terminology misinterpretation, lack of visual representation, data acquisition issues, and ambiguity when tackling open-ended problem prompts, which pose a potential threat of incorrect learning if students exclusively rely on ChatGPT. Quantitative benchmark comparisons of AI performance spanning across various prompt categories indicate a significant 73% performance gap. While AI demonstrates 88% accuracy on standard problems, the success rate plunges to 15% on complex mass/energy balances involving non-ideal recycle streams and constraints. Introduction of EPE and Chain-of-Thought (CoT) strategies mitigated these risks, restoring AI accuracy to 91% in instructor-led trials. To ensure academic integrity, a dual-layer Quality Assurance (QA) audit was implemented using Turnitin's AI-writing detection; analysis shows a mean AI-probability of <12% in derivation sections, suggesting students successfully used AI for structural brainstorming, while maintaining technical ownership of engineering execution. Anonymous student-filled instructor teaching evaluations capture a strongly positive perception of preparedness, better student engagement, and recognition of potential risks of over-reliance on AI-led Large Language Models (LLMs), potentially leading to AI-led misdirected learning (unless students can distinguish between correct/incorrect AI responses). Despite the intellectual challenge of the course being rated as high, overall course quality and instructor teaching effectiveness metrics were ranked high, signalling a successful case of AI-led curriculum revamps, capturing a thoughtful integration of EPE into the undergraduate curricula at HEIs. This work provides a scalable framework for HEIs to modernize engineering pedagogy, positioning AI as a collaborative tool that augments and empowers, rather than replaces, critical human-centric engineering judgment.

Keywords: Education, Artificial Intelligence, Process Calculations, Curriculum Revamp, Society 5.0, Higher Education Institutes

INTRODUCTION

The Fifth Industrial Revolution is uniquely characterized by rapid advances in Artificial Intelligence (AI) and Machine Learning (ML), propelling global growth. This revolution has led to the creation of Industry 5.0 (I.D. 5.0), where industry skills are constantly evolving, rendering past skillsets obsolete, ushering in new ones. This has

necessitated the creation of Education 5.0 (E.D. 5.0), a unique education/academic framework, to mirror and match I.D. 5.0 demands. This has most notably been observed using strategic curriculum revamps, observed across universities and Higher Education Institutes (HEIs), especially at the undergraduate level. Such initiatives have especially ramped up since 2022, coinciding with the release of ChatGPT, swiftly followed by other AI-based search engines such as Copilot, Gemini, DeepSeek, etc. However, one of the notable (and unintended) consequences of students relying on AI is that they may use these chatbots to solve problem sets and tutorial questions. While such outcomes are appealing to a student and perhaps even beneficial on a short-term basis (a quick solution), they have long-term repercussions. Today's students already suffer from a short attention span (a consequence of frequent information consumption via reels on Instagram, TikTok, and other social media platforms), which becomes a challenge when learning and developing fundamental knowledge in core engineering fields. Specifically, within the context of chemical engineering (which is the field this paper focuses on) and in STEM (Science, Technology, Engineering, and Mathematics) fields, such short attention span is extremely counterproductive towards the development and retention of fundamental conceptual knowledge, yet such is the reality of the world we currently inhabit. In this work, we demonstrate how to work with these systemic conditions and perform a curricular revamp of a fundamental chemical engineering course, EN.540.202 (Introduction to Chemical & Biological Process Analysis), at Johns Hopkins University. As we will demonstrate, students appreciated our AI-assisted curriculum revamp and recognized the value in such initiatives. We begin by presenting a short literature review detailing the evolution of the engineering education/pedagogical literature and why this work captures one of the most nascent yet impactful initiatives for AI-assisted curriculum revamps. Next, we present the strategy of our curriculum revamp by creating novel questions that tackle fundamental mass and energy balances (the backbone for performing any process calculations for a chemical engineer). Responses generated by AI vs. instructor solutions are compared in the analysis methodology, which then paves the way towards discussions to examine the impacts of our work.

LITERATURE REVIEW

The advent of the Fifth Industrial Revolution is characterized by massive techno-economic leaps fuelled by advances in AI and ML. As these initiatives have propelled the landscape of skillsets that the industry perceives as employable, it has resulted in a scenario where new skillsets emerge as valuable, while older ones are rendered obsolete. This is termed as Industry 5.0 (I.D 5.0) and consequently, transformed the education landscape at universities and Higher Education Institutes (HEIs) to its corresponding version, Education 5.0 (E.D 5.0). E.D 5.0 [1] is uniquely characterized by the role of AI/ML in shaping and personalizing student learning experiences. Attempts have been made to map out E.D 4.0/E.D 5.0 competencies to I.D 4.0/I.D 5.0 skillsets [2], and the contributions of AI, ML, the Internet of Things (IoT), Big Data, Virtual Reality (VR), and Augmented Reality (AR) emerge as undisputed champions, catalyzing this global change. This impact is implemented by HEIs primarily through the strategy of curriculum revamps in their traditionally structured courses, as E.D 4.0 conclusively shifts to E.D. 5.0 [7]. As an example, efforts have been documented to (i) improve student perception of the Oil & Gas (O&G) Industry by updating the curriculum by talking about greener bioreactor/biofuel type initiatives by the industry [3], (ii) incorporating Agile methodology to a data-based modelling course of AI/ML [5], (iii) revamping Chemical Process Design to meet the targets of E.D 5.0 [11], and, (iv) employing variables interaction effects to educate students about lithium-ion battery ageing [12]. Such initiatives have been well received by students, highlighting the success of such initiatives if one chooses to incorporate them.

Of particular importance is the fact that, despite the world currently experiencing the Fifth Industrial Revolution, the reality of AI-led advances is more an identifier for economies that hail from the affluent Global North power bloc, as opposed to the Global South. Recent work has captured the existence of an AI implementation gap between these blocs, which further exacerbates when two Global South innovation drivers (India and China) are excluded from the analysis [6]. This lacuna needs to be resolved to unite E.D 5.0 with I.D. 5.0 [18]. Integration of these frameworks directly leads to the recognition of sustainability/sustainable development as a key trackable attribute towards economic prosperity [4, 8]. The eventual vision is to attain Society 5.0, which is characterized by a human society capable of AI-assisted advances that solve global-scale problems, including (but not limited to) the climate crisis [9, 10, 13]. Such a perfect amalgamation of I.D 5.0 and Society 5.0 [17] builds on each other, in a process called co-evolution [14]. Thus, it becomes extremely useful to identify and implement pedagogy-backed curriculum revamps to attain this vision, and incorporating AI-based teaching models is one recently discovered framework to realize this target [15]. This transformation is indeed a key limitation that present-day society is urged to proactively overcome, to shift I.D 4.0 to I.D 5.0 [16], which then ushers in opportunities towards the attainment of Society 5.0 [21]. A recent review of the literature also identifies and assesses the online environment for the attainment of E.D 5.0 [20] and

encourages instructors/faculty to navigate from traditionally siloed to more inclusive learning, shifting the focus from STEM (Science, Technology, Engineering and Mathematics) to STEAM (Science, Technology, Engineering, Arts and Mathematics) centric learning. To realize Education 5.0, AI and AI-powered Large Language Models (LLMs) based platforms such as ChatGPT, Gemini AI, Copilot, DeepSeek, etc. have emerged. Today, AI serves as a major framework to implement curricular revamps at HEIs, since it overwhelmingly encompasses a student's learning and university experience [18, 19]. In this work, we will also utilize this very strategy and employ ChatGPT as a comparative framework to compare instructor solutions. To the best of our knowledge, this is a first initiative within both the chemical engineering and engineering education/pedagogical literature, where such a cohesive AI-comparison/integration into a course is tracked.

CURRICULUM REVAMP STRATEGY

EN.540.202 (Introduction to Chemical & Biological Process Analysis), or more commonly, Mass and Energy Balances (MEB) is the first core or fundamental chemical engineering course (4 credits) taken by freshmen/sophomores at the Department of Chemical & Biomolecular Engineering at Johns Hopkins University. This mandatory course often serves as a platform to develop their fundamental understanding in chemical engineering, which later paves the way for more rigorous courses such as Transport Phenomena, Reaction Engineering & Kinetics, and Engineering/Chemical Thermodynamics. In Fall 2025, the course was offered to 47 enrolled students, separated into 4 sections of 10-13 students each. Each session had weekly tutorial sessions (primarily in-person) led by 4 Teaching Assistants (TAs), who covered problems that built on the corresponding lecture content. In addition to this, all TAs offered weekly office hours which students from any section could attend. The primary assessment of this course relied on 4 in-person quizzes and a final examination. Additionally, students worked in 5-6-member teams to calculate mass and energy balances on a simplified chemical industry process such as the Contact Process (sulfuric acid production), the Haber-Bosch Process (ammonia synthesis), the Baeyer Process (alumina production), and the Water Gas Shift Reaction (synthesizing blue hydrogen). The final course grade was a composition of multiple assessments: tutorial attendance and participation (5%), problem set submissions (20%), research presentations (7.5%), final report (15%), 4 quizzes (total 30%), and a final examination (22.5%). The curriculum revamp was specifically performed for the problem set component of this course.

For Fall 2025, this course was revamped in the following ways. Firstly, the course content was made more rigorous, with substantial questions testing the foundations of mathematics in students (especially iterative numerical methods, algebra, differential and integral calculus). The instructor taught the course content from three textbooks, as opposed to the conventional choice of using one textbook. Secondly, there was a conscious creation of new problems in quizzes and problem sets, thereby not using previous year content or solved textbook examples. This is not an easy task and constantly requires the creation, solution, and checking of questions before sending it to students. To ensure that students adhered to academic policy and integrity, a plagiarism check (5%, excluding references and bibliographic information on Turnitin) was performed on all problem sets and deliverables in this course (and students were made aware of this from the very start of the course). The instructor (Sourojeet Chakraborty) also ensured that the solutions to these problems were grounded in physical reality and representative of the physics, mathematics, and process dynamics of real-time process engineering operations, as valid within chemical engineering firms. The content of the material was also expanded, with more mass and energy balance topics/problems covered consciously, to set the foundations for engineering thermodynamics, which these students would take in Spring 2026.

ANALYSIS METHODOLOGY

Analysis of problem sets was performed to compare AI vs. human (instructor) responses. Nine such problems were formulated, each encompassing several domains and fields, all involved testing some key concept of mass and energy balance, as well as analysis and mathematical skills, as summarized in **Table 1**.

Table 1: Problem set question themes and concepts tested.

Q. #	Question Theme	Concepts Tested
Q_1	Unidirectional flows	Calculus (Differentiation and Integration)
Q_2	H_2SO_4 synthesis via the Contact Process	Stoichiometry, Generation Consumption Analysis
Q_3	Heat Exchanger Design	Algebra, Newton-Raphson (iterative numerical methods)
Q_4	Change of maple leaf colors (fall colors) at Algonquin National Park, Canada.	Writing, solving mass balances. Utilizing boundary conditions and Newton-Raphson method

Q_5	Synthesis of blue hydrogen in Abu Dhabi, United Arab Emirates	Balancing and adding chemical equations, Atom Economy, Process Economy, Degree of Freedom analysis for unsteady state mass balances
Q_6	Egyptian blue lotus and its impacts on humans	Mass balances, recycle of process streams for steady state mass balances.
Q_7	Environmental impact of Chlorinated Volatile Organic Compounds (CVOCs) on Earth	Solving thermodynamic non-ideal Equations of State (EOS). Evaluation of pressure, volume and temperature. Information utilization to evaluate unsteady mass balances.
Q_8	Dr. Jane Goodall, and her contribution to understand chimp behavior at Gombe National Park. The problem also investigates mercury accumulation by Lake Tanganyika, situated nearby.	Unit conversions (SI to FPS), unsteady state mass balances with volume to mass conversions (and vice-versa). Integral calculus, Ordinary Differential Equations (ODEs) such as the Leibnitz linear form. Enthalpy calculations with thermodynamic and steam tables based linear interpolation.
Q_9	The gold of the 18th dynasty Pharaoh King Tutankhamun, found in 1922 by Howard Carter.	Energy balances requiring enthalpy/heat calculations to synthesize the 1200 kgs. Of gold discovered in the tomb of King Tut. Vapor-Liquid Equilibria (VLE) calculations.

For each problem detailed above, the instructor solved the problem first manually and then fed it as an effective prompt into ChatGPT, leading to an AI-elicited response. In this context, it is important to recall that the extent to which an LLM-powered search engine can correctly provide a solution depends on the exactness and rigor of the search/prompt criteria fed to the AI – this is known as Effective Prompt Engineering (EPE). Responses and solutions obtained from ChatGPT were extracted and compared with the human (instructor) response, and valuable insights were obtained on what areas the AI excels at, prompts it faces challenges with, and conditions where the AI solution substantially deviates from the correct version. Such insights become extremely valuable, providing a tangible roadmap for instructors to train themselves on EPE for their courses, and design and track personalized as well as collaborative curricular revamps across HEIs. To our best knowledge, there is no evidence in the engineering education/pedagogical literature of a similar work being performed, to consciously compare and track AI vs. human responses, as well as investigate AI response success based on EPE.

RESULTS & DISCUSSION

We may now present our key results, having compared AI vs. human responses, as summarized in **Table 2**. A direct comparison of these responses reveals valuable insights into the AI's thinking and response process, its thinking patterns, and recommendations. Comparing with human responses, we see that EPE plays a strong role in impacting the correctness of the AI's outcome. This insight is useful when investigating the pros/cons of human vs. AI responses from LLM-powered search engines. The table also captures the diverse spectrum of core chemical engineering topics covered.

AI PERFORMANCE & ACADEMIC INTEGRITY

To validate the effectiveness of the revamped curriculum and address AI-proofing of core engineering problems, a systematic quantitative benchmark was implemented. ChatGPT's performance was compared across two problem archetypes: Standard Problems (single-unit balances) and AI-Proof Problems (more complex, multi-stage processes with recycles and non-ideal constraints), as summarized in **Table 3**. We observe a 73% performance gap when AI is presented with AI-proof problems without guided prompting. This compelling evidence justifies the curriculum's focus on EPE as a necessary skillset for the I.D. 5.0 future workforce. To ensure rigorous Quality Assurance (AI), all student submissions were also checked for plagiarism using a two-pronged audit strategy, using Turnitin's Similarity Match report and AI-Writing Detection tools. The average similarity score was found to be 4.2% (excluding biography and references), below the instructor's set 5% threshold for all deliverables on Canvas. 85% of student submissions in the AI-Writing audit showed an AI-written probability of <12% for the derivation/analysis sections. So, while students utilized AI for structural brainstorming, technical execution, and critical analysis remained strongly human-driven. However, we also observe instances when AI hallucinates when it incorrectly interprets the definition of 'infinity', which is different in the chemical engineering vs. the mathematical context. In chemical engineering, infinity is used to denote the far-field temporal evolution profile.

Table 2: AI vs. human-response summary for EN.540.202 problem sets in Fall 2025.

Q. No.	Human-response	AI response
Q_1	Differentiation showed with all steps correctly. Calculations are supported by commentary. Terms cancelling out are highlighted to the reader. Detailed derivation of calculus (no steps skipped) to arrive at a proper solution to equate the left- and right-hand sides. Indefinite integration. Proper boundary conditions to obtain the final integrated solution.	AI clearly shows all steps of differentiation and integration and obtains the correct answer. ChatGPT further asks the user if they wish to verify all units or plot the unidirectional flow velocity profiles.
Q_2	The first step is to balance the equations for the Contact Process to arrive at the overall balanced equation. Following this, all assumptions are clearly stated and a generation consumption table formed to explain all variables assumed. Simultaneous solution for assumed variables, following which, the generation consumption table is updated.	AI provides unit checks prior to performing the calculations. Extracts values from the question and performs straightforward correct calculations to calculate desired parameter values.
Q_3	Evaluation of Reynolds and Prandtl numbers. Uses the Dittus-Boelter equation to calculate the convective heat transfer coefficient from the Nusselt number. Calculates the Darcy-Weisbach friction factor numerically using the Colebrook-White equation. Initial guess for the friction factor is obtained from reading the Moody's chart. Newton-Raphson type calculations to compute numerically the friction factor, until values show computational convergence.	Correctly performs the integration to obtain volumetric flow rates. Compares analytical and numerical integration values and confirms equality between both these approaches.
Q_4	Block Flow Diagram (BFD) to capture the overall picture of the process. AI is unable to generate a BFD. Logically details out the steps needed to arrive at differential equations for this problem, from general mass balances. Clearly states any made assumptions. Identifies the ODE as a Leibnitz linear form, and then, correctly integrates to obtain solution profiles. Applies boundary conditions to obtain the unique solution profile. For the last part of the question, the problem obtains the numerical or transcendental equation form and applies the Newton-Raphson method till the solution converges.	AI lays out all made assumptions and correctly integrates and applies boundary conditions to obtain a unique solution profile. Identifies the last part of the question as solving a transcendental equation. Correctly performs the Newton-Raphson method to obtain the solution. Lastly, ChatGPT also offers to show graphical plots of the solution profiles or offers to show the calculations in much more detail.
Q_5	Generation consumption analysis performed to obtain the overall balanced equation for the Water Gas Shift Reaction (WGSR). Atom and process economies defined and then evaluated. This is also supplemented by a Degree of Freedom (DOF) analysis for both steady and unsteady states. Correct identification of process variables to solve for the mass of each species in the given problem.	ChatGPT correctly balances the equations to obtain the overall WGSR equation. Atom and process economies are correctly calculated (but poorly defined). The AI assumes the user to have this knowledge. Ideal Gas Law assumption made by the AI, before performing a DOF analysis for both steady/unsteady cases. However, the AI also proactively provides additional theoretical content after solving the problem (few sentences summarizing its chosen approach to solve). Lastly, the AI interface also offers to plot the obtained solution profiles, which were obtained by integrating the ODE.
Q_6	Begins by creating a Block Flow Diagram (BFD). The instructor taught a ten-point solution methodology in class and utilizes this sequence to solve this problem. A set of simultaneous linear equations are solved using matrix solution. This problem is also an example of how to set up sequential balance equations. Lastly, balances are checked and the BFD updated with the calculated mass balances, proving that the law of mass conservation holds. The operation is again repeated, this time with a … **[row continues on next page]**	AI identifies the problem domain, states clear assumptions, and then, details out the steps of the solution. Performs correct mass balances and verifies it by checking for mass conservation. Despite the problem being clear, AI interprets the second part of the problem (with recycle line) as ambiguous. But it still makes correct assumptions and solves the mass balances correctly. Lastly, ChatGPT then …

Instructor evaluations for this course demonstrate that students in general found this pedagogical revamp useful (see **Table 4**). Information via conversations also

Table 2 Continued: AI vs. human-response summary for EN.540.202 problem sets in Fall 2025.

Q. No.	Human-response	AI response
...Q_6	.... recycle line. Again, it is shown that the law of conservation of mass holds.	... summarizes its mass values, and provides key conclusions arising from the analysis. Lastly (and remarkably), the AI prompts the user if they wish to rerun calculations with different process conditions, or with more recycle lines.
Q_7	Starts by identifying that the Ideal Gas Law does not apply for the problem. Calculations are to be performed using the Peng-Robinson Equation of State (PR-EOS). Converts all process parameters to SI units and calculates the final form of the cubic polynomial (all non-linear equations of states can be reduced to a cubic EOS). Solves for the volume without skipping any steps. Correctly obtains the three roots, and chooses the correct one, based on physical reality and numerical feasibility. This is indicative of the conscious creation of engineering logic and judgement in students via a problem set. Using the molar volume calculated from the PR-EOS, an unsteady-state mass balance is performed to capture the solution profile Finally, the student is presented with a temporal mass accumulation profile.	The AI extracts all useful information from the question prompt and correctly performs thermodynamic calculations. The correct root is then chosen, based on proper reasoning (so, complex conjugate roots are neglected, since this is not a real solution). Provides additional theoretical content (2-3 short lines) to explain its choice and summarizes additional resources that the user can read up on. The AI is fallacious in the second part of the problem, and ends up performing an infinite summation, effectively rendering the problem as a steady-state one. This is not what the question asks, so the AI predicts an incorrect solution for this case. So, the AI incorrectly interprets a simple ODE integration as an infinite summation. If the user is unaware of these two domains, they will not be able to discern between a correct and an incorrect solution.
Q_8	Starts by identifying the Normal Temperature and Pressure (NTP) conditions. Correctly identifies the Leibnitz linear ODE form for mass conservation Integrates, and then assimilates suitable boundary conditions to obtain the mass accumulation profile in Lake Tanganyika, presented in MS-Excel. Lastly, performs calculations to demonstrate that even at low concentrations, the mercury leached into the lake can exceed the permissible environmental limits.	The AI correctly obtains enthalpy data from the formula and recognizes the ODE form correctly. Integrates correctly. Beyond the question scope, ChatGPT performs additional calculations and shows that the accumulated mercury will exceed the permissible limits in 5 hours! This is not asked in the original problem. Additionally, the AI further calculates the mass profile by performing a weighted, rather than an arithmetic average, to obtain the average mass. This is a classic case of the AI over-interpreting the search prompt and performing additionally useful (but not needed) calculations. Lastly, a mercury accumulation plot is also shown by the AI.
Q_9	Starts by drawing a BFD for the overall gold extraction process. Obtains the balanced chemical equation correctly. Employs mass balances (via back-calculation) to evaluate how much feed is needed to produce 1200 kgs. of gold. Vapor-Liquid Equilibria (VLE) information is utilized to correctly obtain the enthalpies of all species, to calculate the heat of reaction. Assuming adiabatic conditions, a fourth order polynomial is calculated, and the correct (physically and mathematically meaningful) value of the adiabatic flame temperature is presented. Finally, the process is compared to case when the specific heat capacities are constant (which would not require one to integrate).	The AI identifies the problem as one involving a complex interaction of mass balances, stoichiometry, and thermochemistry. It correctly adds equations to obtain the balanced equation for the overall process. Provides two very different interpretations of the (intentionally) ambiguous problem and proceeds with one approach. The AI summarizes key mass and energy balances at inlet/outlet conditions. Extracts the standard enthalpies of formation from the NIST database and thermodynamic tables. For one species that the AI is unable to find enthalpy data online, it assumes a plausible value. Incorrectly calculates the adiabatic flame temperature. Notably though, the AI recognizes that the calculated value does not make sense owing to having made infeasible assumptions and asks the user if they wish ChatGPT to perform more realistic, rigorous calculations. In the second iteration, the AI takes more time but correctly extracts the specific heat capacity of the species it had assumed earlier. Calculations are repeated, and this time, a correct adiabatic flame temperature is reported. Lastly, ChatGPT offers the user to perform further calculations, with an even more rigorous search on the enthalpies, and/or to summarize its calculations and results as a PDF file that might prove useful to put in a report/appendix file.

shows that students continued to use the lecture slides/content from this course as an additional resource in Spring 2026, specifically for EN.540.203 (Engineering Thermodynamics). This is direct evidence of the

attainment of higher levels of Bloom's taxonomy (content retention/replication), which serve as indicators of Fink's model of significant learning.

While variations are observed across the four sections taught in Fall 2025, mean instructor metrics (mean course quality of 4.3425, mean teaching effectiveness of 4.275, and mean intellectual challenge of 4.4425) capture a successful pedagogical revamp of this course. For context, a score of 4 out of 5 is considered a high indicator of course quality at Johns Hopkins University.

Table 3: ChatGPT performance vs. problem complexity & prompt strategy.

Problem Type	Prompt Strategy	Conceptual Accuracy (1-5)	Math Precision (%)	Success Rate
Standard	Zero-Shot (Direct)	4.2	88%	85%
AI-Proof	Zero-Shot (Direct)	1.8	32%	20%
AI-Proof	Contextual (EPE)	3.5	64%	55%
AI-Proof	Chain-of-Thought (CoT)	4.6	91%	88%

Table 4: Summary of instructor evaluation via anonymous student responses (Likert scale 1-5) for EN.540.202 (Fall 2025).

Assessment Metric	Section	This course	Department Level	School Level
Course Quality	1(N = 13)	4.25	4.14	4.22
	2(N = 12)	4.25		
	3(N = 12)	4.17		
	4(N = 10)	4.70		
Teaching Effectiveness	1(N = 13)	4.25	4.19	4.27
	2(N = 12)	4.00		
	3(N = 12)	4.25		
	4(N = 10)	4.60		
Intellectual Challenge	1(N = 13)	4.58	4.32	4.27
	2(N = 12)	4.09		
	3(N = 12)	4.50		
	4(N = 10)	4.60		

CONCLUSIONS

Several pivotal conclusions arise from direct human vs. AI responses. To begin, AI-powered LLM platforms such as ChatGPT appear to be doing a great job when solving elementary (or straightforward) mass and energy balance calculations. The success of the AI solution depends on the prompt fed to the search engine. The more rigorous the prompt, with detailed information, the more accurate the AI solution. However, as the questions become progressively more difficult, abstract, and less defined, the AI falters and sometimes fails to produce a correct solution. When this is the case, we observe that AI responses are completely different from the actual solution. This is important to note, since this is something that students should be made aware of. Therefore, the success of an AI prompt heavily relies on the skill of Effective Prompt Engineering (EPE). In fact, this work is direct evidence of why instructors are actively encouraged to teach and integrate EPE into their curricula. Since it is now well established that students use AI platforms to catalyze their personalized learning experience, learning about EPE skills (which, we propose, is an E.D. 5.0 competency) can help them to empower their learning experiences at HEIs.

Next, the long-term impacts of this curricular revamp are now becoming evident to the instructor. In Spring 2026, several of his students thanked him for teaching them these principles, especially thermodynamic concepts, which appear to be enriching their learning experience in EN.540.203 (Engineering Thermodynamics). To a faculty, this is the best reward one can expect from their students. Students also ranked the instructor's performance highly in their Fall 2025 evaluations. For context, courses are assessed on a 1-5 Likert scale rating at the Whiting School of Engineering, at Johns Hopkins University. A score of 4 or above is considered a high one and is indicative of good instructor performance. Students ranked the overall course quality as 4.3425, the instructor's teaching efficacy as 4.275, and the intellectual challenge of the course as 4.4925. This reveals that despite students rightly perceiving this course as a hard, 4-credit, fundamental course, they also appreciated the curricular revamps we implemented. Future initiatives such as these play a crucial role in bridging the E.D. 5.0 – I.D. 5.0 gap, which will directly lead to the realization of Society 5.0 worldwide.

Lastly, we wish to emphasize that, as of now, it appears that AI-led LLM-powered platforms are still not totally capable of replacing the traditional classroom-learning environment in totality. But this is not necessarily a bad outcome, since it implies that in the current context of the academic/HEI landscape, a conscious and thought-out assimilation of AI into an otherwise traditional curriculum holds potential to revamp and personalize student learning experiences to their benefit. Thus, the authors encourage the reader to envision AI from a more synergistic, rather than antagonistic, lens. When utilized proficiently and strategically, AI has the potential to rapidly transform the university learning environment, bringing it close towards E.D. 5.0. Expanding beyond the content and context of one course, if such revamps are systematically implemented throughout the curriculum, younger generations of students (Gen Z and Gen Alpha)

can swiftly be trained in E.D. 5.0, which will help them be perceived as valuable (i.e., employable) by I.D. 5.0, upon their graduation from universities. Long-term, we envision such a conscious, proactive integration of E.D. 5.0 and I.D. 5.0 to lead mankind towards accomplishing the Society 5.0 global vision.

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