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Study Historical Cases, Learn Today's Tools, and Prepare for the Future

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The rapid development of artificial intelligence (AI) since the emergence of ChatGPT has been overwhelming. The swift transformation that such powerful and disruptive tools brought to the industry urges engineering educators to prepare their graduates not only with the skills to use these new tools, but with an understanding of the ethical and moral implications involved in their applications. Inspired by Marcus Aurelius' quote "To predict the future, we must look at the past," a one-hour tech elective course in a General Engineering program was designed to give students the opportunity to examine historical cases and learn modern tools, equipping them for the workplace in the AI era.

This paper presents a dual-pronged approach used to achieve these goals: (A) studying historical technology and business cases, and (B) learning how to use powerful AI tools such as ChatGPT.

(A) Learning from History: In small, randomly assigned groups, students were asked to watch episodes of the documentary series *The Men Who Built America* and read selected articles from the book *Inspiring Technology: 34 Breakthroughs*. They then presented their findings to the entire class and engaged in Q&A sessions. The documentary explored how Gilded Age tycoons (Vanderbilt, Rockefeller, etc.) dominated industries such as railroads, oil, steel, and automobiles, highlighting the development, cost, and consequences of this industrial growth. The articles from the book showcased experiments and competitions that led to key technological breakthroughs (ex. Maxwell equations, electricity generation, integrated circuits.) over the last two centuries, reshaping modern life. Both sources illustrated the collision of new ideas, technological impact, economic considerations, and political battles, while also exemplifying complex moral and ethical dimensions of these innovations.

(B) Learn AI tools: For a hands-on course project, students were challenged to explore the potential of generative AI tools such as ChatGPT. They learned how to craft prompts for ChatGPT to generate MS-Excel macros, which they then used to process, visualize, and present data from an engineering problem of their choice.

At the end of the semester, a survey was conducted to poll students' perception on how the course prepared them in terms of their awareness of, preparedness for, and willingness to further learn about these tools. A focus group was conducted to collect student opinions on similar subjects. Results from both assessment approaches supported that, after the class, the students believed that they are better prepared for a future with AI and aware of the potential challenges when this tool is applied.

While work introduced here shows promise in addressing the gap that engineering students may experience between their academic preparation and upcoming workplace expectations, a more rigorous course design and thorough assessment are needed for future iterations. This article seeks to share the work-in-progress with conference audiences to gather constructive feedback.

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A. Introduction

Since the public release of ChatGPT in 2022, the AI space has been growing exponentially and received enormous attention from all sectors of society [1-3]. The rapid adoption [1, 2] of such disruptive tools [3] by the industry demands that professionals be adequately ready to use these tools. Professional organizations, institutions of higher-education, government agencies, and public schools all embrace AI with various forms of training (workshops, webinars, forums, symposiums, etc.) to increase awareness, build literacy proficiency, and develop skills. It becomes literally impossible to conduct a complete literature review on new developments and research projects in this area. A simple search in the ASEE conference paper database [4] with "ChatGPT" as the keyword in the years of 2022, 2023, and 2024 generated 0, 37, and 180 hits, respectively, exemplifying the growing interests that AI, particularly ChatGPT, has received from the American engineering education community over the past three years. Most of these studies investigated opportunities of how these new tools support students' learning, from first-year students [5-7] to senior capstone design [8-10]. Some explored ways to enhance writing [11, 12] and other critical skills [13-15]. Many examined potential ethical issues and urged that caution must be applied while adopting AI into instruction [7, 16 – 19]. However, few of these efforts really encouraged or engaged students to prepare themselves for their careers [20-22], although the expectations and requirements for future engineers from the workplace have already been significantly reformed [23, 24].

Contrary to popular belief, college students do not necessarily show the expected sensitivity to new tools and the interest in embracing them. For example, the percentage of engineering students in the aforementioned class who had not previously tried ChatGPT was 50% and 35% in the Fall 2023 and 2024 semesters, respectively. These numbers are on par with those from another study [12], where students in the Construction Management department were polled. It is obvious that much needs to be done to expose students and encourage them to learn the capacities and limitations of these tools.

Preparing students for careers in an era of rapid technological change, driven by disruptions like AI, is a complex task. Graduates will face decisions in their future jobs that extend far beyond the technical knowledge taught in the classroom. They will need to consider factors such as business motivations, intellectual property, ethical dilemmas, moral values, and the social and environmental impacts of their choices. Many of these considerations go beyond what a traditional curriculum can fully cover or teach. The *Contemporary Issues* course presented here aims to bridge the gaps between what the workplace requires and what the typical engineering curriculum offers. Since its first launch six years ago, topics of this course included emerging technologies and their impacts, new advancements and their implications, societal complication in political advocacy/resistance, etc. In previous years, seminars given by guest speakers

followed by enthusiastic discussions have been the primary delivery form. Fall 2024 was the first time that this course was redesigned to prepare students for AI in response to the paradigm shift happening around us.

Inspired by Marcus Aurelius' quote "To predict the future, we must look at the past," the author hopes that by requiring students to learn about disruptive technologies that emerged in the past few centuries, and allowing them to work with today's AI tools, we can enable them to build a strong mindset. This mindset will allow them to recognize the dynamic progress of the development and evolvement of new technologies before they eventually became mature and broadly adopted by users. This hypothesis seems well-supported by *Constructivism*, a theory rooting from psychology, philosophy, and anthropology [25]. Learning from a *constructivist* perspective "is viewed as self-regulatory process of struggling with the conflict between existing personal models of the world and discrepant new insights, constructing new representations and models of reality... and further negotiating such meaning through cooperative social activity, discourse, and debate" [25]. The approach adopted in this course was devised to encourage students to construct their mindsets by repeatedly engaging them in reading about, watching, discussing, and presenting technological breakthrough cases and the moral/ethical difficulties surrounding them. The structure and format of the course were reformed with this new constructivist learning framework, as elaborated next.

B. The Documentary and the Book

The identification of both pieces of teach material (The documentary series [26] and the book "Inspiring Technology: 34 Breakthroughs" [27]) adopted in this course was somewhat incidental:

The documentary: In Spring 2024, after his visit to the Maymont Mansion (https://maymont.org/history/) in Richmond VA, the author wanted to further explore the Gilded Age and found the documentary series "The Men Who Build the America" informative and inspiring. In this documentary series: "*Cornelius Vanderbilt, John D. Rockefeller, Andrew Carnegie, J.P. Morgan, Henry Ford – their names are synonymous with innovation, big business and the American Dream. These leaders sparked incredible advances in technology while struggling to consolidate their industries and rise to the top of the business world... Tracing their roles in the oil, steel, railroad, auto and financial industries, this series uses stunning CGI and little-known stories to examine the lives of these iconic tycoons. How did these leaders advance progress, and what were the costs and consequences of American industrial growth? What role did everyday Americans play in this growth, and how were their voices heard? This series is an excellent companion for course units on business, American history and the Industrial Revolution.*" [25]

Like many historical site visits (Bell Labs at Holmdel, NJ https://www.holmdelhistoricalsociety.org/bell-labs and Thomas Edison National Historical Park https://www.nps.gov/edis/index.htm), the documentary provided the author with a deeper understanding of the industry development taking place in the US, where technological

innovations and entrepreneurship intersect with complex moral and ethical issues. The author believes that the stories in the documentary serve as compelling case study opportunities for students.

The book: The author was given the book by the Education Activities Board (EAB) of IEEE (https://ea.ieee.org/) when he attended the EAB general meeting in April 2024. The book, which celebrates IEEE's 130th anniversary, documents technological breakthroughs in the electrical engineering field. After a quick glance at the book, the author quickly recognized that it could be utilized for the Contemporary Issues class, saving the need to invite guest speakers like the past years. The following passages provide an overview of the book:

"The field of electrical engineering has fundamentally changed the way humans communicate, the way we work, the way we move, learn, heal, create—in short, the way we live. This transformation came in bursts of inspiration, yes, but more often than not, in the slow steady march of tireless experimentation, careful work, and collegial collaboration.

But regardless of their genesis, these advancements didn't happen in a vacuum. Both creative inspiration and diligent endeavor require context, memory, and support…" [27]

The blurb quoted on the right, "I wish I'd had a book like this when I started my career", nicely articulates how the book serves the purposes of the course.

> If you're curious about the innovations that underpin our technology-dominated world, check out *Inspiring Technology: 34 Breakthroughs.* This marvelous book consists of delightful, detail-packed stories about key "breakthroughs" in electrical engineering, from Maxwell's Equations in the 19th century to ChatGPT in the 21st. I wish I'd had a book like this when I started my career as a science journalist.
>
> —JOHN HORGAN Director, Center for Science Writings, Stevens Institute of Technology Author of *The End of Science*, *The Undiscovered Mind*, and *Rational Mysticism*

With the above two pieces of course resources decided, the author created a pool of quizzes related to the stories in the videos and articles. For each story, six questions on factual matters were generated* (with the assistance of ChatGPT). The questions were divided into three groups, each with two questions. A student must answer one question from each group.

C. Constructivism and the Structure of the Course

A constructivist view of learning suggests an approach to teaching that gives learners the opportunity for concrete, contextually meaningful experience through which they can search for patterns, raise their own questions, and construct their own models, concepts, and strategies. The classroom in this model is seen as a mini society, a community of learners engaged in activity, discourse, and reflection [25]. Based on this belief, the structure of the Contemporary

* with the assistance of ChatGPT 3.5.

Issues class was developed with the constructivist framework in mind, where important pedagogical elements[**] include:

1) Active Engagement: Reading (or watching) stories about technological breakthroughs immerses students in narratives that illustrate the challenges, experiments, and successes involved in innovation. This engagement helps them relate personally to the material, making the learning experience more meaningful.
2) Contextual Learning: By exploring historical stories of technological advancements, students can see how specific innovations emerged in response to societal needs and challenges. This contextual understanding helps them recognize that innovations are not just products of creativity but also shaped by the environment and user feedback, which is crucial for their future careers.
3) Building Connections: By reading about past technological breakthroughs, students can draw parallels to contemporary innovations, understanding the processes that lead from initial ideas to widely used products. This ability to make connections fosters critical thinking and adaptability, skills that are essential for their future careers.
4) Reflection and Meaning-Making: As students read, present, and discuss stories about the development of technology, they can reflect on the implications of these innovations for individuals and society. This encourages them to think critically about how they might contribute to future technological advancements in their own careers.
5) Collaborative Learning: Students discuss and present stories in groups, allowing insights and different perspectives on how past innovations had been shaped, preparing them for collaborative work environments in their future careers.

During the semester, a class session typically followed the steps below:

1) The week before, students were randomly divided into three groups; each group (five or six students) was assigned with their documentary episode (or article from the book) that they were required to complete before the next class time. To ensure the students had indeed completed the watching or reading, they were required to complete the quiz for each of these assignments.
2) In the first 20 minutes of a class, students were sent to breakout rooms so that they could go over the story they had watched (or read) in the past week and decide how they wanted to present the story to the rest of the class (the other two groups)
3) The three groups were brought back to the main room. Each group presented their story, each member talking about a different part or explained from a different perspective.
4) After each of the group presented their story, students from the other two groups asked questions regarding the story just presented.

[**] ChatGPT 3.5 was utilized to create this list.

5) The presentation and Q/A time for a story usually took 25 minutes, resulting that an entire class usually ran between 75 to 85 minutes.

Before they were sent to breakout rooms, the students were reminded to pay attention to moral and ethical issues that their story may involve or entail.

ChatGPT Course Project: The project required the students to investigate the capabilities of ChatGPT and gain insights into its advantages and potential implications when it's applied to engineering. The project consists of two main parts: (a) use ChatGPT to generate VBA macros to achieve the data processing and data visualization needed for an engineering problem that is of the interest of the student, and (b) discuss ChatGPT's potential applications and possible concerns in the context of the engineering profession.

Since most of the students in the class were seniors who were busy with senior capstone projects and other engineering courses, the project was assigned in the beginning of the semester and completed by the middle of the semester, ensuring it did not conflict with other course deadlines.

D. Assessment and Results:

At the start of the semester, the author was uncertain whether students would actively participate in all course activities, including individual reading, group discussions, presentations, and Q/A sessions. However, the course proved to be a success. Student attendance and engagement were outstanding — nearly all 17 students maintained perfect attendance, except for one student who had to miss several weeks due to a full-time job commitment. The 90-minute sessions were consistently well-attended and fully engaged. The discussion sections were particularly lively, with students asking thoughtful questions and offering insightful responses, especially when discussing moral and ethical issues. The end of class student survey results and the focus group session further confirmed the instructor's positive perception:

a. Student Survey

A twenty-question survey was conducted to gauge students' perceptions of AI technologies, the ethical issues involved in innovation, and their opinions on the three components of the course (i.e., documentary, book, and project). The questions used a five-point scale (1 – Strongly Disagree; 5 – Strongly Agree). All seventeen students participated in the survey. Seven of the questions focused on AI, with the results shown in Figure 1. Students reported that the course project helped them better understand the power of AI tools like ChatGPT (4.65), feel more prepared (4.47), and recognize the need to learn more about these tools (4.35). However, they were less enthusiastic about taking actions to continue learning (3.76).

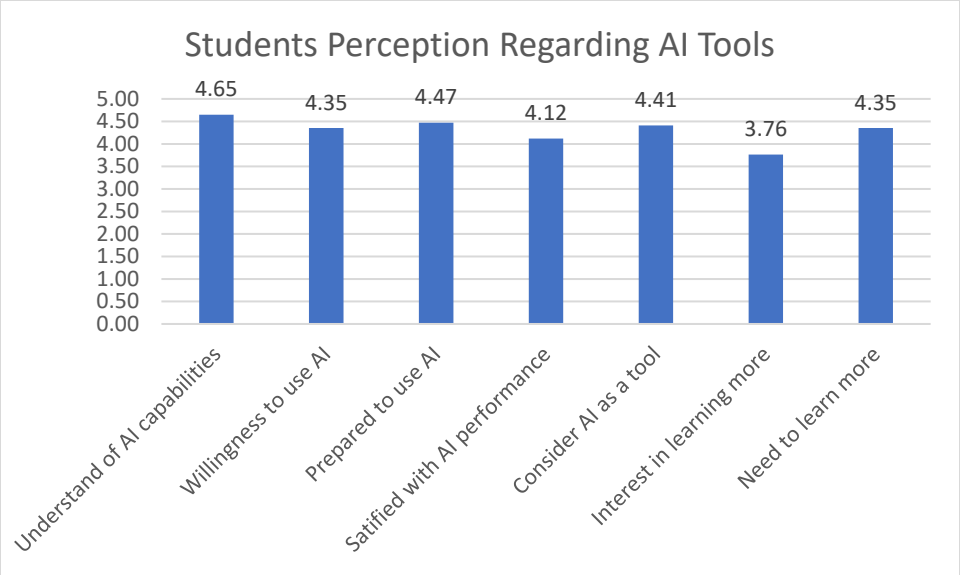

Figure 1. Students' perception on AI tools

Figure 2 presents the students' perceptions of the ethical and moral issues explored in their case studies. From the book reading and documentary viewing, students clearly recognized the long-term consequences of past business and engineering decisions (4.53). They acknowledged that new technologies could bring both benefits and harms (4.41) and believed it is important to learn more about the ethical implications of using AI tools in the future (4.35). The survey results also indicated that the students acknowledged that balancing innovation with ethics can be challenging (4.24).

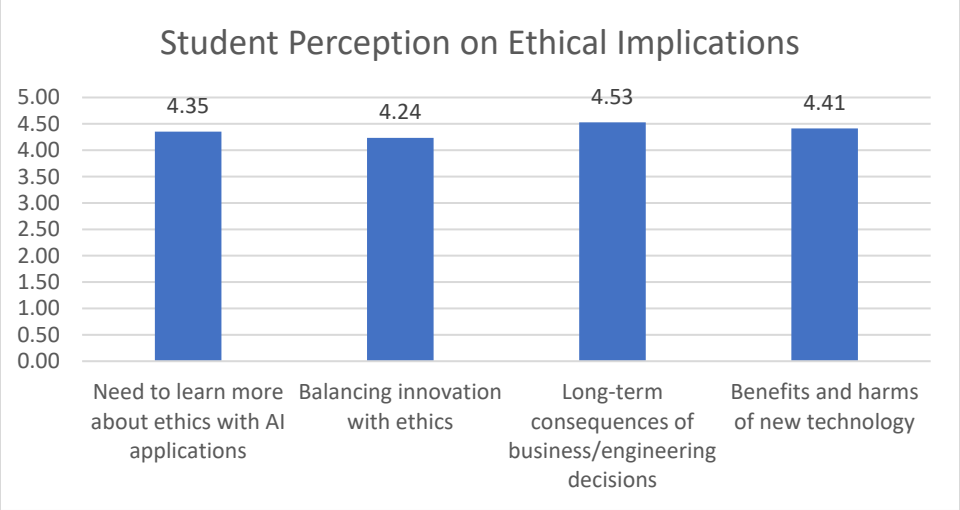

Figure 2. Students' perception on ethical implications

b. Focus Group

The final session of the class was conducted as a focus group following the reading of "Attention Must Be Paid" from [27], an article that explores the potentials and risks of AI technologies like ChatGPT. Guiding questions were provided in advance to encourage student reflection. The session lasted approximately 45 minutes, during which all students shared their thoughts. The summary that the author believes accurately reflects the essence of the discussion (see below) was generated [***]. This summary qualitatively shows the positive experience the students had in the class.

"The main takeaway from this class discussion revolves around the growing awareness and application of AI, specifically ChatGPT, in various fields, particularly in engineering. Students reflected on their experiences using AI tools, expressing surprise at the capabilities of ChatGPT in areas like data analysis, coding, and creating visualizations like graphs. Many participants shared how they previously had limited exposure to AI, and the class broadened their understanding of its potential to simplify tasks and enhance productivity.

However, ethical concerns were a recurring theme. Students acknowledged the risks of AI spreading misinformation due to "hallucinations" (incorrect but convincing data), biases in AI training, and the potential for malicious use, such as in deepfakes or scams. There was also concern about over-reliance on AI, particularly in tasks like writing or decision-making, which could impair critical thinking and intellectual skills over time.

Additionally, the class delved into the historical context of technological development, with discussions on how figures like John D. Rockefeller shaped industries through ethically questionable practices. This led to broader conversations on how technological advancements, including AI, can disrupt industries and society, with both positive and negative impacts.

In conclusion, the students appreciated the opportunity to learn about AI's potential while also critically considering the ethical implications and challenges associated with its integration into the workforce and daily life. They recognized AI as a powerful tool but emphasized the importance of maintaining human oversight, creativity, and ethical standards in its use."

E. Discussion

Using a one-credit-hour engineering technical elective course to engage students with AI (ChatGPT) was an initial, intuition-driven attempt by the instructor, but it appears to align well with the constructivist theory of learning. The author acknowledges that this work lacks the desired thoroughness in several areas. First, the *Inspiring Technology: 34 Breakthroughs Celebrating 140 years of advancing technology for the benefit of humanity* book used in the course, an IEEE publication, focuses primarily on electronics, magnetism, optics, and communication, among other topics. While the two pieces of material seemed to serve the

[***] ChatGPT was utilized to interpret the recorded scripts with all student names removed.

author's purpose of encouraging students to learn from the past, and students appreciated the stories, the stories lacked diversity in terms of representing technological breakthroughs. The documentary series "The Men Who Built America" focuses on the 20th century industrial capitalism. Using it in a course could cause concern of taking an unnecessary stance deeming engineers and industrialists as heroes in social development.

Secondly, more insightful survey questions and more in-depth analysis are needed to better understand students' learning and attitudes. Thirdly, using ChatGPT to interpret students' collective perception–despite removing identifiable information–may be seen as controversial. These shortcomings stem in part from the author's limited training in learning theory, time constraints, and, more importantly, the lack of existing literature on this rapidly evolving subject, where regulations, policies, and recognized practices are still developing. Rather than avoiding these contradictions, this article seeks to share the trial effort with conference audiences and gather feedback to improve these areas.

F. Future Works:

While this work-in-progress shows promise in addressing the gap that current engineering students experience between their academic preparation and the upcoming workplace expectations, more rigorous course design and thorough assessment are needed for future iterations. The author plans to refine the course to organize it more systematically within a theoretical learning framework. If possible, educational experts will be invited to collaborate on designing experiments and formally assessing the outcomes. The author also plans to reexamine the learning materials to include technological advancements from broader fields and select materials that more objectively reflect history and development. Hopefully these efforts will provide students with a more comprehensive view of technological progress and enhance their learning experience.

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