

Re-Designing an Energy Systems Course with Generative AI

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Abstract

This paper describes one instructor's first approach at integrating Artificial Intelligence (AI) tools in course design and the generation of multi-faceted case studies and assignments. The course, Energy Systems, is an elective course for upperclassmen in undergraduate Mechanical Engineering. Topics covered include power generation (fossil fuels, nuclear, solar, hydro, and wind), as well as emerging technologies, local and global trends, sustainability, and policy related to the energy sector. The course materials require significant updates with each offering to stay current with the swiftly changing energy landscape. To update the course materials and assignments for the latest offering of this course, the instructor utilized AI (Microsoft CoPilot) to help generate new case studies that included the traditional, technical engineering analysis found in many textbooks, as well as considerations for sustainability, policy/regulations, and the impact on the local community. Assignments were created to better align with the Engineering for One Planet (EOP) framework to further integrate sustainability concepts and challenge students with more robust engineering analysis and decision-making. The instructor also compared course outlines from previous offerings with topics suggested by the generative AI software to evaluate alternatives to the traditional course calendar.

This paper includes sample AI prompts, modifications to prompts, and the resulting output. The results include a discussion of erroneous information generated by AI and identify course design elements that were made more robust with the assistance of AI. Instructor feedback highlights perceived benefits and challenges from a first experience using AI as a course preparation tool.

Introduction

The integration of generative artificial intelligence (AI) in education, particularly in undergraduate engineering courses, has garnered significant attention in recent years. A 2024 literature view of generative AI in higher education focused on 37 journal articles published from 2023-2024, from a selection of more than 100 articles available in Scopus and Web of Science [1]. AI remains a hot topic in higher education with the potential for far-reaching benefits as the technology advances. Potential challenges and drawbacks are also being highlighted as both students and instructors begin adopting these technologies and applying generative AI to teaching and learning, including over-reliance on AI [2, 3, 4].

Multiple studies are investigating the use of generative AI tools to improve educational outcomes by offering personalized feedback, facilitating adaptive learning environments, and providing on demand resources to assist with student learning [2, 5, 6]. Other studies focus on the potential to streamline the course development process and align course materials, assignments, and assessment schemes with course objectives [6]. There is also particular interest the potential of generative AI tools to support innovative teaching practices and improve student engagement [7]. Institutions of higher education and centers for teaching are publishing guidelines and best practices for AI use to help students, faculty, staff, and administration navigate this new frontier [8].

Literature reviews of generative AI in higher education by Batista *et al.* [1] and Tillmanns *et al.*

[6] provide a snapshot of AI tools being integrated at all levels of the teaching and learning process, with positive outcomes resulting when human oversight and intervention. While ChatGPT receives significant attention in the exploration of generative AI applications in education, alternative tools are also being studied [1, 6]. Microsoft Copilot is gaining popularity, with some studies investigating Copilot's role in enhancing engineering education [7].

This paper describes one instructor's first approach at integrating generative AI, via Microsoft Copilot, in course design and the generation of multi-faceted case studies and assignments. Feedback is provided on the effectiveness of simple prompts and modified prompts that provide additional detail/constraint. Opportunities and challenges are also noted.

Methodology

As a first approach at integrating generative AI in the course design process, the instructor limited themselves to Microsoft 365 Copilot, an AI-powered productivity tool that is available with a Microsoft account. The free version of the tool with enterprise-grade security, privacy, and compliance, was accessed using the instructor's university email address and Microsoft 365 account. The version of Microsoft Copilot used to generate materials was based on GPT-4 architecture. Additional features and upgrades may be accessed by purchasing the Pro version for more experienced users were not included in this study.

Microsoft Copilot has a user-friendly interface that can be accessed via web browser in Microsoft 365 as a chat window. The free version chat was limited to 30 responses before being asked to create a new chat. The mode of Copilot can also be toggled between **Creative**, **Balanced**, or **Precise** mode. Microsoft offers many helpful resources, including onboarding, a prompt gallery, examples, and online training to help familiarize users with functionality and methods for achieving desired results when using the tool. Additionally, there are numerous websites, discussion forums, and publications with tips for building effective prompts for AI tools.

To revamp the latest offering of the Energy Systems course described in this paper, the instructor consulted Copilot for recommendations on textbooks, course topics, course outlines, key analysis methods, case studies, emerging technologies, future challenges, and desirable skill sets for mechanical engineer entering the energy sector. The prompts for Copilot were created by the instructor, modeled from helpful resources, and suggested by Copilot.

Creating Prompts

Available resources suggest creating prompts with increasing levels of detail to effectively generate AI responses. Some of these recommendations may deter instructors from exploring the benefits of tools like Copilot. However, even simple prompts resulted in useful suggestions for the course re-design described in this study.

Recommendations for prompts include identifying the goal, context, source, and expectations [9.]. Prompts can be further enhanced by identifying a role for the AI tool using phrases like, "as an experienced mechanical engineering professor, [insert prompt]." Specific sources can be listed, or general phrases like, "using academic journals and peer-reviewed publications," or,

“cite sources,” can enhance reliability. AI tools like Copilot can also “hallucinate” and cite sources that do not actually exist; reviewing the generated responses for accuracy is imperative.

As a beginner-level user of Copilot, the instructor also queried the generative AI tool with the following prompts:

- *How can Copilot best help me design a course on energy systems for undergraduate mechanical engineering students?*
- *What prompts should I use in Copilot to help me re-design an existing undergraduate course for mechanical engineering students?*

Both prompts resulted in new ideas for the instructor to explore. In many ways, Copilot can act as a brainstorming tool and assist instructors in both creating and refining course elements.

Results

Course Outline & Key Topics

To update the Energy Systems course described in this study, the key topics listed in the course outline from the 2023 offering of the course were compared with suggested topics and timelines from Microsoft Copilot. Responses generated by Copilot were compared across multiple chats. One chat originated with a prompt for a 14-week course outline, while other chats included reference to the 2023 outline, reference to textbooks, and/or reference to the EOP Framework.

The instructor supplied Copilot with multiple prompts to create a course outline in multiple chats, including prompts asking for revisions to the previously generated outline. Some prompts mentioned the EOP Framework, the previously adopted course textbook, the six textbooks suggested by Copilot, and/or ABET accreditation. Copilot was prompted to take the perspective of an experienced mechanical engineering professor, a pedagogical expert, an energy expert, and as an ABET evaluator. Each prompt included the targeted audience of undergraduate mechanical engineering students and the specification of a 14 weeks. Overall, the outlines generated by Copilot were similar when using both **Balanced** mode and **Precise** mode of the browser chat.

Additional prompts were used to identify essential and emerging topics that may be covered in an Energy Systems course independent of the course outline, as summarized in Table 1. Many of the topics included in the generated course outlines, or listed in the sub-bullets for the general topics, were repeated in the new responses from Copilot.

Table 1: Prompts to Identify Topics of Interest

Prompt	Generated Response
What are the 5 most important topics and Energy Systems course should cover for undergraduate students in mechanical engineering	(each item included a description and list of key concepts) 1. Energy Production & Conversion 2. Renewable Energy Technologies 3. Energy Storage Systems 4. Energy Efficiency & Conservation 5. Sustainability & Environmental Impact

Please review the course syllabi for ABET EAC accredited mechanical engineering programs in the US and provide a summary of common topics taught related to energy systems and energy production.	(each item included sub-bullets of key topics) <ol style="list-style-type: none"> 1. Thermodynamics 2. Heat Transfer 3. Fluid Mechanics 4. Renewable Energy Technologies 5. Energy Storage Systems 6. Energy Efficiency & Conservation 7. Power Generation & Distribution 8. Sustainability & Environmental Impact 9. Advanced Energy Systems
Which thermal science analysis techniques should be covered in an undergraduate Energy Systems course for seniors majoring in mechanical engineering?	(each item included sub-bullets of key topics) <ol style="list-style-type: none"> 1. Thermodynamic Analysis 2. Heat Transfer Analysis 3. Fluid Mechanics 4. Energy Conversion Systems 5. System Modeling & Optimization 6. Experimental Techniques 7. Case Studies & Applications
Identify and provide a brief description of 5 emerging technologies that will increase efficiency or improve sustainability in energy production	(descriptions removed for brevity) <ol style="list-style-type: none"> 1. Advanced nuclear reactors 2. Floating offshore wind turbines 3. Perovskite solar cells 4. Grid-scale energy storage 5. Green hydrogen production
What are the top 10 emerging technologies and trends in the energy industry	(each item had sub-bullets for technologies and trends) <ol style="list-style-type: none"> 1. Advanced Energy Storage 2. Green Hydrogen 3. Carbon Capture, Utilization, & Storage (CCUS) 4. Smart Grids 5. Floating Offshore Wind 6. Distributed Energy Resources (DERs) 7. Electric Vehicles (EVs) 8. Artificial Intelligence (AI) & Machine Learning 9. Microgrids 10. Energy-as-a-Service (EaaS)
What skills and knowledge does a mechanical engineer need to prepare for a career in the energy industry in the USA	(one of five categories listed in response) <u>Industry-Specific Knowledge</u> <ol style="list-style-type: none"> 1. Renewable energy technologies 2. Energy storage 3. Grid modernization 4. Environmental regulations 5. Sustainability practices

Based on the course outlines and suggested concepts generated by Copilot, the instructor modified the course to include a full week dedicated to ‘Energy Distribution & Management,’ which would cover topics like Smart Grids and Microgrids. These topics were not explicitly listed in the previous course outline but were briefly presented in a single class meeting, along with grid decentralization. Other changes included reducing the time devoted to wind energy and regrouping or renaming a few topics, as shown in Table 2.

Table 2: 2023 Course Outline and updated 2025 Course Outline

Week	General Topics (2023)	General Topics (2025)
1	Introduction to Energy Systems & Thermodynamics Review	Introduction to Energy Systems & Thermodynamics Review
2	Thermodynamic Cycles and Using EES	Energy Conversion & Using EES
3	Energy Production (Fossil Fuels), Conversion & Storage	Energy Production & Conversion
4		Fossil Fuel Energy Systems
5		Nuclear Energy Systems
6	Carbon Capture and Sequestration & Greenhouse Gases	Energy Storage
7	Nuclear Energy	Energy Distribution & Management
8	Wind Energy	Environmental Impacts, Sustainability, & Policy
9		Wind Energy Systems
10	Hydro Energy & Pumped Storage	Hydropower Systems
11	Sustainability & Policy	Bioenergy & Geothermal systems
12	Solar Energy	Solar Energy Systems
13		Solar Energy Systems
14	Bioenergy, Fuel Cells, Etc.	Emerging Technologies

Assignments & Case Studies

After identifying Smart Grids and Microgrids as an important topic to add to the course, Copilot was prompted to draft outlines for a lesson plan. The initial prompt, “as a mechanical engineering professor, draft an outline for a lesson on Smart Grids,” resulted in a lesson outline for a 90-minute lesson broken down into 10-20 minutes segments with suggested topics and activities. The outline also included learning a suggested learning objective, assessments, and

recommended reading. The learning objective generated by Copilot was, “to provide students with an understanding of smart grid technologies, their components, benefits, challenges, and the role they play in modern energy systems.”

The instructor followed this response with prompts for Copilot to modify the lesson plan for a 50-minute class meeting and to draft a quiz for students after the lesson with feedback for student responses. Copilot can generate sample questions in a variety of formats and suggest feedback for both correct and incorrect student responses. Providing more detail in the prompt, such as addressing each level of Bloom’s Taxonomy, following inclusive practices, or adding societal context, can further refine Copilot’s responses. Here is a sample question generated by Copilot for smart grids [10]:

“How do smart grids facilitate the integration of renewable energy sources?

- a. by storing excess energy in batteries*
- b. by using advanced sensors and communications technologies*
- c. by reducing the need for energy storage*
- d. by eliminating the use of non-renewable energy sources*

Correct Answer: (b)

- *Feedback for Correct Response: Correct! Smart grids use advanced sensors and communication technologies to manage and integrate renewable energy sources effectively. This integration helps reduce greenhouse gas emissions and supports the transition to a more sustainable energy future.*
- *Feedback for Incorrect Response: Incorrect. While energy storage is important, the primary way smart grids facilitate renewable integration is through advanced sensors and communication technologies, which are essential for managing variable renewable energy sources.”*

When generating draft assessment materials, instructor review and curation are important for ensuring factually correct and appropriate questions. Switching to Copilot’s **Precise** mode can enhance the responses from Copilot when generating more specific content. **Balanced** mode provides a good starting point and allows more creativity when exploring opportunities with Copilot’s assistance. Generative AI offers opportunities to develop and improve assessment tools, including practice problems with automated feedback that could be added to an LMS system or developed as an interactive AI study tool.

Copilot was also promoted to draft a two-paragraph description that connects smart grids and microgrids with the EOP Framework, resulting in a prompt that could assist the instructor to further integrate the EOP Framework when delivering the lesson. For instructors brainstorming new ways to present material or connect topics, generative AI can provide multiple suggestions for the instructor to evaluate and consider.

Copilot identified eight categories of course design for which it could provide assistance. Those categories included Content Creation, and Assignments and Projects. Within these categories, the

generative AI tool offered support in creating “*real-world case studies and examples to illustrate key concepts and engage students,*” and “*group project ideas that encourage collaboration and practical applications of knowledge.*” These suggestions closely aligned with the instructor goals to leverage generative AI to introduce more robust case studies when updating a course.

One prompt suggested by Copilot was, “*What are some relevant case studies to include in a course on [specific subject] for mechanical engineering students?*” Instead of a specific subject, the instructor also tried specifying an energy source, an energy technology, and a type of energy system to generate various responses. Based on the original draft, the instructor prompted Copilot to modify the case study. Helpful modification requests included asking to include more technical detail, to use current economic data for a specific location, to cite sources, to reference specific sources, to emphasize thermodynamic analysis, to address the EOP framework, and more. It was not uncommon for Copilot to suggest follow-up prompts that predicted things the instructor was interested in. With more experience, prompts could be improved to require fewer iterations when generating a case study or problem state that matches that instructor’s intent.

After modifying a case study or problem statement to the instructor’s specifications, the instructor found it helpful to prompt Copilot to, “provide a sample solution for this assignment.” Results for sample solutions and sample rubrics could also be modified with follow up prompts to include all elements desired by the instructor. Sample solutions may contain errors and should be reviewed for accuracy.

Copilot can generate equations and was prompted to include equations in sample solutions to case studies or problem statements for students to analyze. However, the equations were in-line text and not formatted as a symbolic equation when prompting Copilot to, “include efficiency calculations,” to modify a solution for solar energy case study while in Copilot’s **Balanced** mode. Switching to Copilot’s **Precise** mode led to responses that included formatted, symbolic equations. Variables were still defined with in-line text, but **Precise** mode was superior at handling equations and symbolic variables.

Copilot seemed more limited in the creation of figures, especially engineering schematics and diagrams. Formatted plots were created without providing raw data, but it required more detailed prompts for the data to represent the requested variables and to do so in an accurate way. The instructor observed decreased reliability, and occasionally non-sensical results, in figures generated from simple prompts. This study does not include an evaluation of Copilot within Word, Excel, or PowerPoint, although Microsoft provides tutorials and helpful resources for those applications, too.

Discussion & Conclusions

This study is limited to a single, beginner-level experience in course re-design using generative AI. The instructor was impressed with the responses generated by Copilot from simple prompts, as well as the prompts suggested by Copilot.

For a new instructor, tools like Copilot could significantly reduce the initial prep-time required when designing a course. It may be especially helpful for outlining key topics to cover in a week, or single class period, until the new instructor gains some experience in estimating the time required effectively teach a topic. Copilot will also provide suggestions for textbooks and can draft a course outline that includes daily topics, corresponding textbook chapters, and suggested assignments and activities. Although AI-generated content still needs to be reviewed and adapted by instructors, the powerful technology may help instructors quickly climb the steep learning curve when building a new course. The scope of this paper does not include full course development, but this instructor was impressed with ability to quickly generate drafts of course outlines, syllabi, lesson plans, assignments, assessments with feedback, and more.

In this study, the instructor was updating an existing course they had taught multiple times in the past. While the changes to the course outline were relatively minor, the process was a valuable exercise for the instructor. Textbook content, instructor expertise, and historical experience both shape and refine a course outline over repeated offerings, and it is easy to fall into a routine. Generative AI tools like Copilot can help instructors quickly assess the current course offering and identify potential topics to add or remove to meet the changing needs of students and the profession.

When updating an existing course, Copilot can help instructors draft learning objectives, develop lesson plans, identify active learning activities and strategies, draft assignments/quizzes in different formats with questions that address all levels of Bloom's taxonomy, and much more. While updating the Energy Systems course described in this paper, the instructor used Copilot to identify helpful resources and improve their understanding of Smart Grids and Microgrids, draft an outline with key topics to cover, and develop new assignments while teaching about energy distribution and management. The instructor also used Copilot to identify current and emerging technologies, summarize data on energy production and consumption by different locations, find price data and policy information, and more.

It was found that creating a new chat was beneficial in generating responses based on new or different sources. Results could then be compared between chats in an attempt to remove bias "learned" by Copilot based on your earlier interactions. For example, while in the same chat session with Copilot, after including a prompt related to the Engineering for One Planet (EOP) framework, many of the subsequent responses referenced EOP or included similar language from an earlier response. More similarities were seen in the generated responses after uploading a PDF with the 2023 course outline in a prompt to update the current course offering. Entering the prompt "*new topic,*" can also refresh responses in Copilot.

Generative AI is providing powerful opportunities for instructors and will challenge the ways teaching and learning are approached. The potential benefits are seemingly limitless, but it is important to consider the ethical and societal implications as outlined in numerous publications. Generative AI tools cannot be trusted blindly and generated content should be verified and checked for accuracy and bias. The instructor found it helpful to require the AI tool to provide sources when evaluating the accuracy of some claims generated in response to a prompt. Facing

a new frontier, this study offers a glimpse of how Copilot can support course updates using simple prompts. Alternative AI tools with different capabilities may be more effective in creating specific technical content.

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