Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #46308

Applications of Artificial Intelligence in an Introductory Thermodynamics Course

Lt. Col. Jason Daniel Christopher, U.S. Air Force Academy

Lt Col Jason Christopher is an assistant professor of mechanical engineering. His research interests include thermal fluid sciences and pedagogical innovation. He holds a Ph.D. in mechanical engineering from the University of Colorado, Boulder and an M.S. in mechanical engineering from Rice University. He is an engineer in the U.S. Air Force and has experience acquiring space launch range systems and directing operational tests of multi-billion-dollar systems.

Vincent Italo Bongioanni, United States Air Force Academy
Prof. Lauren Scharff, U.S. Air Force Academy

Lauren Scharff is the inaugural Director for the Scholarship of Teaching and Learning Program and a Professor in the Department of Behavioral Sciences and Leadership at the United States Air Force Academy (USAFA). Prior to working at USAFA, she was a Prof

Applications of Artificial Intelligence in an Introductory Thermodynamics Course

Abstract

As students and faculty grapple with the introduction of artificial intelligence (AI) into higher education, it is imperative that universities keep up with the latest trends and capabilities to equip their students to function beyond the classroom. In this work, we introduce a variety of AI tools into an introductory thermodynamics course within a mechanical engineering curriculum. Students are taught AI fundamentals along with basic query techniques applied to engineering-relevant examples throughout the course. Several applications of AI are utilized during many lessons of the course including providing enhanced motivation for example problems, providing alternate explanations of course learning objectives and content, finding relevant applications of course concepts, as well as studying for quizzes and exams. Additionally, specific, varied AI concepts are applied to thermodynamic processes to understand AI's broad use beyond generative large language models (LLMs) AI that permeate popular discourse. Student familiarity and sentiments regarding AI are collected at the start and end of class to understand how the course activities influenced their perceptions of AI's utility. By exposing students to many facets of AI, with a focus on engineering applications, we seek to develop student capabilities utilizing AI in working through their academic and professional duties.

1 Introduction

Technology improvements are a part of the human story from the earliest of our historical records, controlled fire and rolling wheels in prehistoric times, to automobiles and computers in modern times. Each of these changes has brought about questions about the pros and cons of a given technology compared to the status quo that led to that point. Tractors and sophisticated farm equipment like combines reduced the number of workers required to produce our agricultural yields needed to feed an ever growing population. Calculators shortcut our basic arithmetic skills and led teachers to wonder what skills and proficiencies students need to be able to succeed in mathematics, while Mathcad eliminated previously cumbersome steam-table lookups.[1] Today, artificial intelligence (AI) leads to similar questions about what skills are innately human and which abilities are okay to be offloaded to computer processing, freeing the human mind to contemplate and pursue other tasks and objectives. This paper investigates current capabilities within AI applied to students in an undergraduate thermodynamics course and how AI can help them achieve the course's learning objectives.

This effort studying AI within a mechanical engineering thermodynamics course comes as part of a larger effort within the United States Air Force Academy to look at how AI is being used across all of the curriculum to develop best practices and understand faculty perceptions regarding AI's role in higher education. That effort focuses specifically on two tracks: students and faculty. The student focus examines AI within the classroom for learning activities to determine its influence on students' sense of belonging, academic performance, and critical thinking skills. The faculty track examines how faculty use AI for non-teaching centric tasks as well as seeking to understand the faculty perceptions on the role they think AI plays within their courses, from developing material to helping administer and grade exams to figuring out the guardrails for allowing students to use AI on assignments, as well as on their professional development needs.

The more focused effort discussed in this paper implements AI throughout the undergraduate thermodynamics course and evaluates student perceptions of AI within an engineering curriculum. The approach includes several separate AI-focused methods to create content for students to use. Many lessons utilized AI-generated summaries of the material or AI-generated images to accompany and motivate examples. Students used AI to generate example questions to review the material and prepare for quizzes. Lastly, diverse types of AI were shown to students in applications that help engineers solve tough nuclear power plant design, operational, and training challenges. Students completed pre- and post-course questionnaires with Likert-scale and open-ended questions to see how the AI activities influenced their perceptions of AI. The results of these surveys and identified trends are identified herein.

2 Background

Tools to increase an engineer's technical capabilities have been an important research area for many decades. Various improvements to calculation devices, for instance, have enabled ever faster and more precise results from the slide rule of the 1600s to its eventual replacement, the personal electronic calculator of the 1970s, and then to computer-based software and computational methods. Wolfram Alpha made a large step forward in the ability to solve a variety of problems and explain the steps to learners everywhere.[2] Now, AI, and specifically large-language models (LLMs) such as ChatGPT provide the next evolution in solving complex problems while showing detailed commentary on every step and calculation made. But AI's ability to aid an engineers in their endeavor to solve the world's technical challenges is much more broad. A brief review of AI's definition, emergence, and varied types is appropriate.

2.1 Artificial Intelligence Definition

A term as broad as 'artificial intelligence' is bound to have many definitions, most with significant overlap, but all with slight variations and nuances depending on the particular application and context. An early book on the topic by Earl B. Hunt defined AI by the topics that it sought to help address at the time of publishing his manuscript (1975): "theorem proving, game playing, pattern recognition, problem solving, adaptive programming, decision making, music composition by computer, learning networks, natural-language data processing, and verbal and concept learning."[3] Obviously by modern standards (of 2025), this list is deficient as AI has grown so much (e.g. creating original artwork of many forms, not just music). The Department of Defense

AI Strategy takes a much broader approach simply defining AI as "the ability of machines to perform tasks that normally require human intelligence."[4] Thus, this paper will adopt this definition to encompass many applications that may not fall within the traditional concept of what AI can accomplish in a classroom.

2.2 The Rise of Artificial Intelligence in Everyday Life (i.e. why engineers need to know it now)

Artificial Intelligence has risen in popularity the last several years with the release of ChatGPT to accomplish a variety of activities that were previously viewed as science fiction relegated to moveies and the imagination. Before this wide-spread adoption throughout may sector of society, however, AI had been on a steady rise as computer computational power has increased in the latter half of the 20th century. Alan Turing introduced the idea of talking with a computer and not being able to tell if it is a computer or a human, the task since dubbed a "Turing Test," in an important but never published manuscript in 1948.[5] (Indeed his hypothetical capability is now common practice in foreign language classes so students can practice their conversational skills even when another person who knows that language is not present.) Computer scientists continued improving AI capabilities with significant milestones along the way including when IBM's Deep Blue defeated the reigning chess champion of the world, Garry Kasparov, in 1997.[6] Its growth accelerated at the start of the 21st century with life-like chatbots emerging,[7] autonomous vehicles taking to roads,[8] vast image recognition improvements,[9] winning Jeopardy! in 2011 against the best human contestant ever to compete[10], and culminating with the plethora of large-language model (LLM) interfaces such as OpenAI's Chat GPT-3 and Google's Gemini,[11] in addition to AI-driven image (Dall E[12,13]) and video (Runway[14]) generation software. With this infiltration of AI into many facets of our lives in recent years, it is crucial to consider what AI-centered skills students will need as they enter the workforce, as well as what faculty can do to prepare them. Indeed, some companies have already expressed a preference for AI skills over experience and that they will not hire a candidate without AI skills.[15]

2.3 Primary Subsets of Artificial Intelligence

With the recent progress in AI, it is important to understand the various types of AI currently in use. A clear definition of the types of AI will help provide context for what students will need to be familiar with in the workplace as well as what they can utilize in class to propel their learning of thermodynamics. Though there are many ways to categorize the main types of AI (e.g. IBM's classification based on capability vs function[16]), the breakdown by Akkio[17] is more indicative of what students will see in engineering practice. Akkio lists the main subsets of AI as: machine learning (to include deep learning, neural networks, and natural language processing), robotics, and genetic algorithms.[17] Machine learning uses large data sets to train and make predictions about other data inputs based on the training set; machine learning includes many different approaches to making sense of large sets of training data to include large language models such as ChatGPT. Robotics focuses on using AI to control physical systems such as robots or vehicles. Finally, genetic algorithms seek to find how well postulated solutions fit the desired outcome and then iterate based on the best options at each step. Note that all of these approaches to AI can be used and applied to different types of data from numbers, speech, images, etc. and thus have

applications across engineering education.

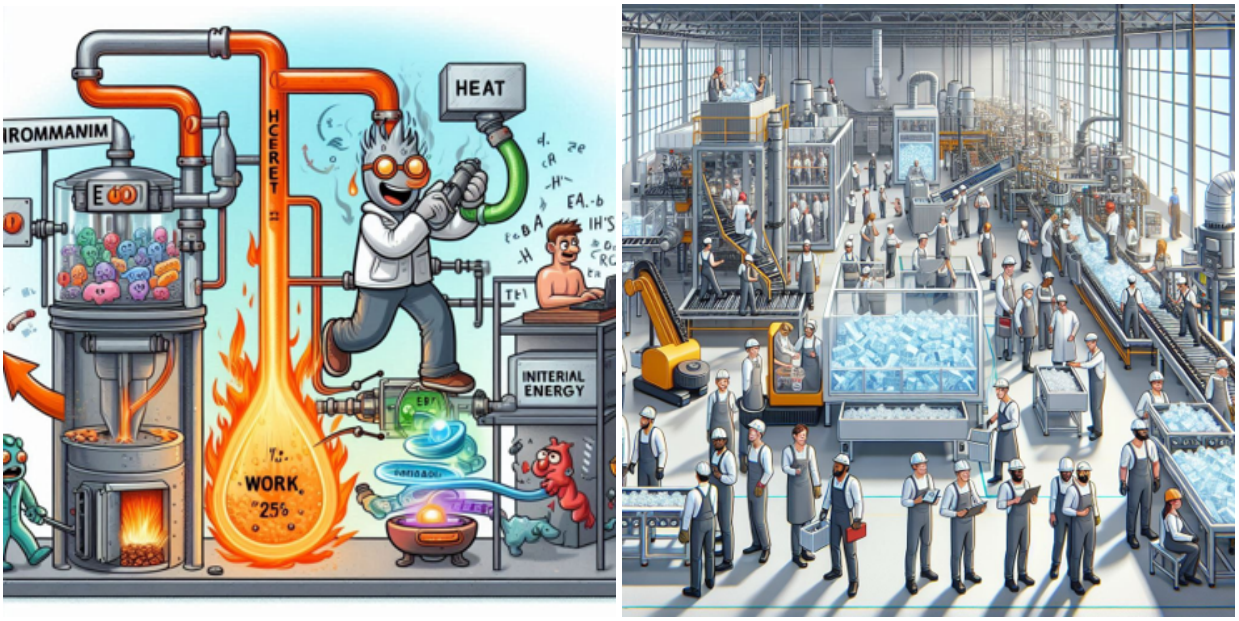
2.4 Applications of Artificial Intelligence to Teaching Engineering

AI is becoming ever more present in daily life, to include within the education domain. The recent book, *Teaching with AI*[18] provides specific guidance for how to utilize AI in the classroom from honor policies to quiz and exam approaches. The book, and other prominent work on teaching with AI ([19],[20]), are generic to all disciplines, however, so it is important to focus on how to utilize AI effectively for engineering education, and specifically thermodynamics. Menekse posits some of the benefits as well as the challenges of using AI in an engineering education.[21] Specifically, the work by Menekse highlights the personalized learning experience AI can provide, AI's potential to create virtual learning laboratories, AI can provide real-time, individualized feedback on student work, and students can use AI to 'learn by teaching.'[21] Menekse's warnings about AI focus on its potential to spread incorrect information (which students need to be aware of and can serve as a learning opportunity for students to identify such errors), privacy concerns for student data shared with software, decreasing the cognitive load for students which causes them to learn less (i.e. the one who does the work does the learning), and students are tempted to plagiarize AI outputs depending on the course policies.[21] There is very little research focused on using AI within thermodynamics, but Supan[22] made a large contribution in this area by having students analyze various applications of AI to regulate nuclear power plant operations. Through this effort, Supan demonstrated the power of AI in solving or optimizing very specific engineering tasks, helping her students understand AI's potential within thermodynamics.[22] Though these works lay the foundation for teaching thermodynamics using AI-informed approach, the current effort seeks to build upon this foundation and identify additional pedagogical approaches for using AI in the classroom.

3 Research Approach

Several AI-focused activities were chosen for implementation in the semester-long introductory thermodynamics course. The intent was to expose students to a variety of AI applications so they could see its relevance to their learning and to engineering applications. These activities complemented traditional course pedagogy including regular textbook reading assignments, homework, laboratory exercises, and periodic learning assessments including quizzes and exams. The AI exercises and exposure were ungraded but intended to be an initial exposure for students to explore the many ways by which AI can integrate into any engineering course, with a few of the activities specifically tailored toward thermodynamics-specific content.

The specific AI-focused learning events included the following, some of which occurred nearly every lesson and others that occurred as needed to support key semester milestones. A large language model, OpenAI's ChatGPT, was used extensively for various exercises, so students were first taught the fundamentals of prompting to obtain relevant results. The Prompt Engineering Guide[23] provided the key points for students (and faculty) to use when developing prompts. With this prerequisite established, the course introduced various AI-aided learning methods throughout the course. As part of many lessons, students reviewed AI-generated summaries of the concepts then attempted to critique what was present and what was missing. Students practiced for 9



(a) Thermodynamics Cartoon

(b) Example Problem Image

Figure 1: (a) Image created by Dall-E to demonstrate thermodynamic concepts. Students considered the various types of energy transfer it portrayed and critiqued as appropriate such as it labeling the apparent flame as "work" instead of "heat." Created using the following prompt: Create an introduction to thermodynamics cartoon style image with labels for 'heat', 'work', and 'internal energy.' (b) Image created by Dall-E to make an example problem about an 'ice factory' more interesting and visual to help with student retention. Created using the following prompt: Create an image of the interior of an ice making factory.

different quizzes using AI-generated multiple choice questions for topics specific to each quiz (see Figure). The instructor provided AI-generated images to complement and motivate otherwise generic example problems (see Figure 1 (b)). The course utilized AI to help elaborate on course concepts and provide additional examples of concepts relevant to student interests. Students also looked at AI-generated data, such as the image in Figure 1 (a), to determine what AI rendered correctly and where it missed the mark. The course also highlighted the examples from Supan[22] to show that in addition to simpler applications of AI to classroom exercises, the same techniques can be used to solve sophisticated thermodynamics applications.

To collect data about the effectiveness of these AI-focused activities, surveys were taken at the beginning and the end of the course. Surveys were voluntary, results were de-identified, and participation counted for no points, but time during class was given for students to complete them. The surveys asked a variety of questions to assess several objectives, in line with the university-wide AI project effort. Namely, the objectives include the following:

1. Examine the effects of AI among university students on learning outcomes and processes
2. Evaluate how AI-driven teaching tools can be purposed for personalized and inclusive education

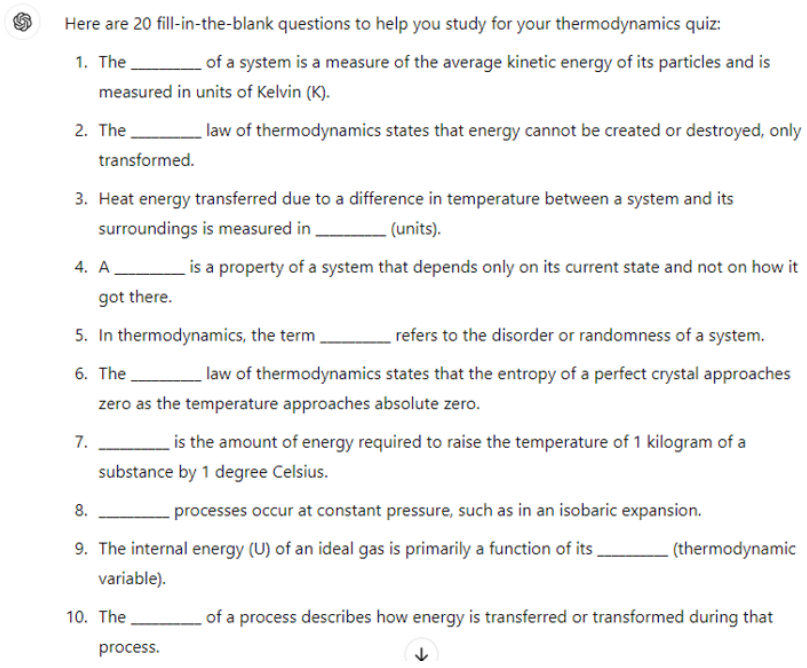


Figure 2: Example fill-in-the-blank quiz created by ChatGPT to help students practice their understanding of thermodynamic concepts. Created in ChatGPT-4 using the following prompt: Generate 20 fill in the blank questions to help me study for a thermodynamics quiz covering basic thermodynamics vocabulary and units.

3. Explore the ethical dimensions and practical challenges of AI use
4. Understand how the integration of AI into classroom settings alters student-teacher and student-student dynamics
5. Explore and compare the perceptions of instructors and students regarding the use of AI

A review of student responses in pre- and post-course questionnaires will enable evaluation of these five objectives. The questionnaires had Likert-scale questions as well as free-response questions. Students were given time in class to complete the voluntary questionnaires which were worth zero points.

4 Discussion and Results

The instructor integrated AI activities into the 40-lesson semester-long thermodynamics course and offered pre- and post-course surveys to the students to understand their perceptions of AI before the experience and after the AI applications. Though the questionnaire was optional and worth no points, of the 23 students in the single-section course, 23 students responded to the pre-course questionnaire while 20 of those students responded to the post-course questionnaire. Despite the overall number of students being relatively small, the high participation rate (87%) indicates the results likely represent the class as a whole. Each questionnaire contained a combination of 7-point Likert scale questions and open-ended questions. For the 7-point Likert scale questions, the options were: Strongly disagree, Disagree, Slightly disagree,

Undecided/Unsure, Slightly agree, Agree, and Strongly agree. These responses are sometimes described in the results section as the percentage of students who agreed or disagreed which could account for any of the modifiers (including strongly or slightly); for example, a reported response could indicate that 52% of students agreed which indicates that 52% of students selected either strongly agree, agree, or slightly agree. Since the questionnaires contained many (52) questions each, and the overall number of responses is relatively low, this discussion will highlight the general trends observed in students as well as responses aligned with the project's five objectives. Questions not directly discussed were deemed by the authors to be inconclusive or have insignificant results. Figure 3 shows the results from questions described in the text below. Each question's label describes if it was from the pre- or post-course questionnaire as well as which research objective it is connected with.

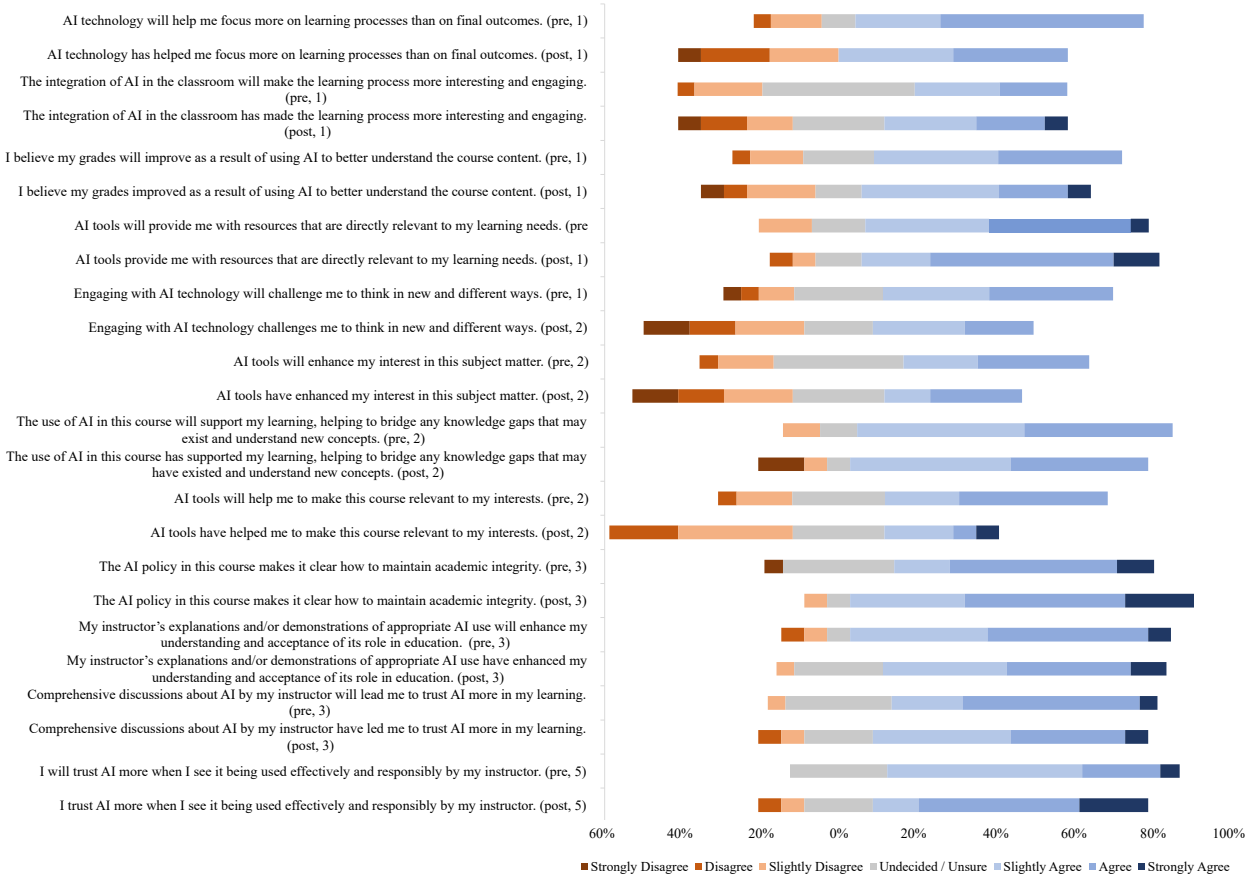


Figure 3: These questions are a subset of the total 52 asked in the questionnaire; these questions are addressed in further detail in the results section. Each question's response is shown from the pre- or post-course questionnaire as indicated after the question text. The number after the text for each question indicates to which of the five research objectives it corresponds. Results are centered about 0% being the middle of the undecided band going left (orange colored) indicating disagreement or right (blue colored) indicating agreement.

4.1 Overall Student Feedback

A series of questions in the post-course questionnaire asked students about their overall experiences using AI in the course and their impressions of it going forward. Students identified several primary advantages of using AI in the thermodynamics classroom, including its ability to enhance their understanding of class concepts and provide clarity to complex ideas through answers customized however one would desire; one student wrote, "AI is able to take very complex ideas and make them understandable at whatever level you want. If you want the process of air conditioning units to be explained at a 4th grade level, that is something you can do." Thus, generative AI programs can align with where students are in their learning journey, reinforcing learning by explaining complex topics in digestible prose. AI is also helpful for explaining concepts in logical steps so students can follow along, unlike days of yore when textbooks would arrogantly state, "it is left to the reader." Instead, AI solves problems while providing helpful instructions to the student to follow along; one student commented, "AI can be very helpful in explaining a step by step process for going through the homework."

Along with these advantages, however, students were keen to note some substantial difficulties with using AI in the classroom. Their primary concerns from the start of the semester continued through the semester after many examples in class that AI can have accuracy issues. It hallucinates to make up data at times or does calculations incorrectly. Students also had issues in a thermodynamics context performing problems that rely on book tables for property values, stating, "it was often wrong calculation-wise (especially with the table values)." Students also had concerns about becoming too reliant on using AI to do the work and not learning how to solve problems or understand the material on their own - the enduring question of open book vs closed book! Thus, overall, students thought AI was a useful tool to supplement learning, but expressed that it cannot serve as the primary source in place of instructors, textbooks, homework, etc.

As the course progressed and students were exposed to AI more each class, they generally became more comfortable with using it to help understand concepts and solve problems in an engineering class. However, they remained skeptical of its results and continued their skepticism and desire to verify its outputs. One student wrote, "I trust AI a lot more than I use to because I'm better able to tell what's true and what's not. In the beginning I was more scared of honor than anything else." This emphasizes the importance of clear policies by instructors and institutions regarding AI's acceptable use in the classroom for learning and each assignment, as will be discussed more in Section 4.4.

4.2 Research objective 1: Learning Outcomes and Processes

The first objective of the overarching AI study (of which this thermodynamics focused effort is a small part) is to understand AI's impact on learning outcomes and processes for students. The survey results help provide insight into how much students thought AI could help them in the classroom. At the start of the course, 73% of the students thought AI would help them focus on learning processes, while only 60% agreed at the end of the course. This could be due to the emphasis in engineering of both the learning process but also the end result, which is crucial for planes that fly, cars that drive, and power plants that produce: the end product matters. AI's use in the classroom encouraged more students to find the class material interesting with only 39%

agreeing AI would make class more interesting and engaging while 47% thought it actually did at the course's end. Another key metric of AI's success is how students view its ability to impact the grade in a positive manner; 63% thought their grade would improve by using AI to better understand course content and this remained consistent through the course with 59% of respondents agreeing in the final survey, while only 12% reported disagreed or strongly disagreed. Overall, the majority of students thought AI helped them achieve learning outcomes and that it provided timely feedback on their work. Overwhelmingly, 76.5% agreed that AI tools provide students with resources that are directly relevant to their learning needs while only 12% disagreed. The largest shift toward negative responses was that engaging with AI technology challenged students to think in new and different ways; originally 59% of students thought it would, but in the end only 40% thought it did.

4.3 Research objective 2: Personalized and Inclusive Education

The second line of inquiry for the research project was to investigate how AI is able to personalize the learning experience for students and foster an inclusive environment for education, which can increase students' sense of belonging in the course. Many students thought AI would increase interest in the subject material (thermodynamics), but in the end only 35% of respondents actually thought AI made thermodynamics more interesting while 40% of people did not agree. Despite this shortcoming, 76% thought AI supported learning by bridging knowledge gaps based on their previous education and helped increase their understanding of new concepts. The majority agreed AI allowed learning to occur at their own pace and in their own style, and that it helped overcome their specific educational challenges and learning barriers. A large portion (37%) thought AI did not help make the course relevant to their interests; this could stem from a lack of emphasis from the instructor in helping students understand AIs potential to connect an engineering concept to an area they are more interested in. It is important to note that these results are not simply a summary of the current state of perspectives from the 20 students in a single class– the results speak to pros, cons, and directions that instructors can take as part of a continuous improvement process.

4.4 Research objective 3: Ethical Dimensions and Practical Challenges

The third research objective peels back the mystique of AI and looks at the ethical considerations of using it as well as the practical challenges students face. This was not an emphasis area of the course as there are many topics related to the ethical use of AI including data privacy, fair access by all users, biases in the data, and fair accounting of who produced the answers (i.e. academic integrity). This latter aspect (academic integrity) was the primary ethical consideration in this study. Many of these ethical areas are less relevant to thermodynamics as the primary homework and exam questions students used AI for are focused on numerical calculations, and students all used free versions of the software or versions paid for by the university accessible to all students. In general, students reported that they started the course confident about how to use AI ethically and they felt their understanding was reinforced by the course. The strong majority of students ($>$70%) reported in the questionnaire that they felt like they knew the boundaries for what AI use was allowed based on course and school policies, were comfortable talking about AI and academic integrity with the instructor, and thought the instructor's guidance helped them gain trust in AI's uses for learning. This is encouraging as the university where this study occurred

places a substantial emphasis on academic integrity and students take an honor oath while attending school. These trends indicate students are becoming comfortable integrating AI into their academic experiences, but more research is needed to determine whether they appreciate the broader ethical complexities with using AI. Primary concerns from students included the gray areas of how much AI assistance is permitted and them wanting more instructor-driven examples of proper AI use for assignments. Additionally, more efforts are needed by the university and faculty to ensure the other 30% understand the boundaries and appropriate uses for AI.

As faculty determine their own fair use policy for AI, it is relevant to share the boundaries by which this course approached using AI on assignments. In line with the university and department policies, this course allowed AI on homework and laboratory assignments while requiring students to document its usage consistent with receiving help from another resource (such as help from a classmate). Each assignment type has unique limitations. Quizzes and tests, for instance, are individual effort so no outside help is authorized. Homework and laboratory write ups authorize help from other students, but the work must be primarily that of the submitter. Thus we require students to specifically state what they received help on for a given problem (e.g. help with a particular stein a problem, how to start, where to get a property) vs blanket statements such as receiving help for an entire problem. This fidelity of documentation both discourages academic integrity lapses while allowing faculty to understand where students struggle most. One of the most important aspects in deciding how students can utilize AI is to be clear and keep it simple so the student has no ambiguity when working on an assignment, perhaps late at night or under pressure when ethical inhibitions may be waning.

4.5 Research objective 4: Student-Teacher and Student-Student Interactions

The fourth research objective sought to determine how AI impacted student-teacher and student-student interactions. Overall, questionnaire results changed very little between pre- and post-course data regarding these topics. The current study did not place a large emphasis on this topic so it makes sense that students' questionnaire results did not change much due to taking the course. Additionally, there was an even split between those who agreed and those who did not agree, indicating students differed in their perspectives, including whether AI changed interactions with the instructor, whether they were more efficient or productive, whether they needed instructor time more or less, whether they would work with peers differently, whether they would be more productive with peers, and whether they would use AI to engage and interact with classmates. While AI's use for working out problems and understanding concepts was widespread, its impact regarding human interactions was quite varied. Some of the students who found a difference regarding instructor interactions noted that they had a decreased reliance on instructors since they used AI for quick, simple simple questions or as a first step in problem-solving, which reduced their need to interact with instructors for basic queries. Indeed, one student commented, "AI is a great way to prepare for the instructor as it adds another step in problem solving method: try myself, ask AI, ask another Student, ask Instructor." Thus, students use AI as a preparatory step before seeking help from instructors to refine their questions or better understand the material beforehand. Students noted that AI is highly accessible and convenient as it provides immediate responses, making it a preferred tool for initial problem-solving, especially for straightforward or repetitive questions. AI provides a non-judgmental space for students to ask

questions they may feel uncomfortable asking instructors, particularly for topics they think they should already know. Despite AI's utility, some students indicated a preference for instructor explanations due to their depth and alignment with course-specific nuances.

4.6 Research objective 5: Perceptions of Instructor and Students regarding use of AI

The final research objective this effort seeks to address concerns how faculty and students perceive using AI in the classroom setting. The larger research project will span many courses and many instructors, but this current effort is limited to the experiences of a single instructor. According to this instructor's perspective, AI was useful for creating engaging materials. It succinctly summarized complex topics to create quick review materials for students while offering them an additional resource to consult in addition to the traditional options - textbook, instructor, classmates, and the internet. From the students' perspective, 71% said they trust AI more when instructor uses it effectively. Thus, at this juncture it is crucial to develop trust in the technology and appropriate usage habits among students. The majority of students agreed that it helps when the instructor shows how to fact check AI, combating one of their primary concerns about AI - whether they can trust its results. Students indicated that instructor examples helped them figure out how to use AI with their own problems, so instructors should focus on providing good use cases. Lastly, students' comments showed that AI enhanced the quality of the educational content in the course. These data indicate that AI can be an effective tool to increase learning in thermodynamics and likely other engineering courses.

5 Limitations and Future Directions

Though this research effort is able to discern important trends with using AI in the thermodynamics classroom, it has some limitations worth considering. First, there was only one section of the course offered with 23 students, so the sample size is limited. This effort was not able to compare students engaging with AI activities to students not using the AI activities; instead it relied on the students' self-reported experience in the course and their own comparisons to other courses that do not use AI. Similarly, with only a single section there was only one instructor, so it is not possible to compare one instructor's implementation of AI with another instructor to see what works well and what does not, for instance. The data used for this effort were student surveys instead of student grades or other more objective measures of performance. With multiple sections it would be helpful to compare and contrast performance, time spent on assignments, and time spent with faculty for extra instruction in a section that uses AI and a section that does not use AI to see the similarities and differences. The last major limitation of this effort was its focus on particular implementations of AI in the classroom, namely large language models through limited interface applications. It would be helpful to grow the number of tools demonstrated to students and have them implement different assignments using varied AI to best understand its multitude of real-world applications.

6 Conclusions and considerations for implementation

Students enjoyed using AI in the classroom and recognized it will be an important tool moving forward within academia, the workforce, and throughout society. This sentiment was captured

well by one student, who wrote "restricting it completely is a disservice to students as the world changes." Thus, students want to be prepared to use it in conjunction with other tools. Through this effort it became clear that students, despite all the credit they are due for embracing new technology, are still learning how to use AI, so they expect instructors to provide clear, explicit examples of how it can help them learn, think critically, and solve problems. It's important to note that some students are still resistant to using AI in the classroom; when asked about how instructors should best utilize AI to aid learning they simply responded "Stop" or "Please do not [use AI]." However, after seeing AI's clear application in the classroom and experimenting with it to solve problems, understand concepts, and study for quizzes (among other tasks), the majority of students supported AI in the classroom as a tool to support their learning, although they cautioned against relying on it too much. One student asserted, "I will always consider using AI, however, I will always verify the information that it provides me." Students in this course also stressed the importance of clear AI usage policies to empower them to use it effectively while avoiding honor situations. Students overwhelming reported that they plan to keep using AI in future classes and other life endeavors. After all, that is a foundational purpose of education – to empower students to think about problems and teach them tools to move forward in life. All of these points combine to strongly suggest that AI is an important component of a modern-day classroom, and that instructors ignore it at their, and their students', peril.

The views expressed in this presentation are those of the author and do not necessarily reflect the official policy or position of the United States Air Force Academy, the Air Force, the Department of Defense, or the U.S. Government. Approved for public release: distribution unlimited. Public Affairs Number: USAFA-DF-2025-268. US Air Force Academy IRB Approval: FAC20250011E

References

[1] Jason Christopher, Adam Parks, Vipul Sharma, and Michael Maixner. Power plant analysis with mathcad. In *2008 Annual Conference & Exposition*, pages 13–987, 2008.

[2] Vincent E Dimiceli, Andrew SID Lang, and LeighAnne Locke. Teaching calculus with wolfram— alpha. *International Journal of Mathematical Education in Science and Technology*, 41(8):1061–1071, 2010.

[3] Earl B Hunt. *Artificial Intelligence*. Academic Press, Inc., 1975.

[4] Department of Defense. Summary of the 2018 department of defense artificial intelligence strategy: Harnessing ai to advance our security and prosperity, 2018.

[5] Alan Turing. Intelligent machinery (1948). *B. Jack Copeland*, page 395, 2004.

[6] Feng-hsiung Hsu. Ibm's deep blue chess grandmaster chips. *IEEE micro*, 19(2):70–81, 1999.

[7] Nuria Haristiani. Artificial intelligence (ai) chatbot as language learning medium: An inquiry. In *Journal of Physics: Conference Series*, volume 1387, page 012020. IOP Publishing, 2019.

[8] Martin Buehler, Karl Iagnemma, and Sanjiv Singh. *The DARPA urban challenge: autonomous vehicles in city traffic*, volume 56. Springer Science & Business Media, 2009.

[9] Frank Y Shih. *Image processing and pattern recognition: fundamentals and techniques*. John Wiley & Sons, 2010.

[10] John Markoff. Computer wins on 'jeopardy!': Trivial, it's not. *The New York Times*, 16, 2011.

[11] Nitin Rane, Saurabh Choudhary, and Jayesh Rane. Gemini versus chatgpt: applications, performance, architecture, capabilities, and implementation. *Performance, Architecture, Capabilities, and Implementation (February 13, 2024)*, 2024.

[12] Gary Marcus, Ernest Davis, and Scott Aaronson. A very preliminary analysis of dall-e 2. *arXiv preprint arXiv:2204.13807*, 2022.

[13] Pengyuan Zhou, Lin Wang, Zhi Liu, Yanbin Hao, Pan Hui, Sasu Tarkoma, and Jussi Kangasharju. A survey on generative ai and llm for video generation, understanding, and streaming. *arXiv preprint arXiv:2404.16038*, 2024.

[14] Biying Guo, Xinyi Shan, and Jeanhun Chung. A comparative study on the features and applications of ai tools-focus on pika labs and runway. *International Journal of Internet, Broadcasting and Communication*, 16 (1):86–91, 2024.

[15] Rachel Wells. 71% of employers prefer ai skills above experience in 2024. *Forbes*, Nov 2024. URL `https://www.forbes.com/sites/rachelwells/2024/11/05/71-of-employers-prefer-ai- skills-above-experience-in-2024/`.

[16] IBM Data and AI Team. Understanding the different types of artificial intelligence, 2023.

[17] Ekin Keserer. The six main subsets of ai: (machine learning, nlp, and more), 2023.

[18] José Antonio Bowen and C Edward Watson. *Teaching with AI: A practical guide to a new era of human learning*. JHU Press, 2024.

[19] David Baidoo-Anu and Leticia Owusu Ansah. Education in the era of generative artificial intelligence (ai): Understanding the potential benefits of chatgpt in promoting teaching and learning. *Journal of AI*, 7(1):52–62, 2023.

[20] Stefan AD Popenici and Sharon Kerr. Exploring the impact of artificial intelligence on teaching and learning in higher education. *Research and practice in technology enhanced learning*, 12(1):22, 2017.

[21] Muhsin Menekse. Envisioning the future of learning and teaching engineering in the artificial intelligence era: Opportunities and challenges. *Journal of engineering education*, 112(3), 2023.

[22] Karen Supan. Using artificial intelligence case studies in a thermodynamics course. In *2024 ASEE Annual Conference & Exposition*, 2024.

[23] Democratizing Artificial Intelligence Research Education and Technologies Group. The prompt engineering guide, 2024.