Paper ID #45824

Generative AI in Engineering: Tool or Trouble?

Dr. Claire Lynne McCullough PE, High Point University

Dr. McCullough received her bachelor's, master's, and Ph.D. degrees in electrical engineering from Vanderbilt, Georgia Institute of Technology and the University of Tennessee, respectively, and is a registered professional engineer in the state of Alabama. She is currently Professor and Founding Chair of Electrical and Computer Engineering at High Point University, and teaches courses in such areas as Engineering Ethics, Controls, and Engineering Design. Dr. McCullough has over 30 years' experience in engineering practice and education, including industrial experience at the Tennessee Valley Authority and the US Army Space and Missile Defense Command. Research interests include Data Fusion, Bioinformatics, and issues of Diversity and Under-representation in STEM fields.

Dr. Mike Dalton, High Point University

Dr. Dalton received his Bachelor's, Master's, and Ph.D. degrees in Electrical Engineering from the University of New Hampshire. He is currently a Professor of Computer Science at High Point University. Dr. Dalton has taught Computer Science courses at the university-level for 20 years, and has delivered many courses in C++, Java, Python, Digital Circuit Design, Robotics, Database Development, Project Implementation, Business Information Systems, Applied Modeling and Simulation, Distributed Programming Concepts, and Cybersecurity. His research interests include Intelligent Systems, Linguistic Models, Artificial Intelligence, AI Prompt Engineering, and Computer Science education.

Generative AI in Engineering: Tool or Trouble?

Introduction

The publicity surrounding Generative Artificial Intelligence (GAI) and its possible uses has led to much excitement and speculation about the role that these tools can play in technical education and in the practice of engineering and computer science. Some possible uses that have been hypothesized for professional use are brainstorming, report writing, proposal composition, authoring training materials and creation of PowerPoint presentations, as well as technical aspects such as code creation, fault detection, circuit layout, and large system design. For students, these uses could include creation of study guides, generation of practice problems and solutions, and idea creation. Some professors are even experimenting with using generative AI to grade and provide feedback on student work. While some of these uses can provide potential benefits to students and professionals, ethical issues must also be addressed: AI "hallucinations," over-reliance on the tools, changing definitions of plagiarism, copyright issues, and environmental impacts of the technology [1]. This paper provides an overview and exploration of a selection of the existing tools, an examination of the caveats associated with GAI use, and a beginning discussion of the ethical considerations that must be addressed.

What is all the fuss about?

Artificial Intelligence, and its potential uses, have been in the news for decades. Many first became aware of the potential of AI to meet or exceed human capabilities in May of 1997, when Garry Kasparov, the reigning world chess champion, was defeated by IBM's Deep Blue. The match was carried out under standard chess tournament rules and controls, and consisted of a series of six games, which resulted in one win for Kasparov, two wins for Deep Blue, and three draws. This was considered significant, in that chess is an extremely complex game, and was regarded as "an ideal test of whether a computer could rival the power of the human brain." Deep Blue used "brute force computing power" and 32 parallel processors to achieve a speed of 11.38 billion flops, enabling it to evaluate 200 million chess moves per second. According to IBM, "Deep Blue wasn't just a breakthrough for the world of chess. Its underlying technology advanced the ability of supercomputers to tackle the complex calculations needed to discover new pharmaceuticals, assess financial risk, uncover patterns in massive databases, and explore the inner workings of human genes [2]."

IBM once again made the news in a breakthrough of human intelligence vs. machine in 2011, when its Watson computing system appeared on the television quiz show Jeopardy and defeated its two "greatest of all time" champions, Ken Jennings and Brad Rutter. Unlike Deep Blue, Watson was trained to "read, listen and understand" natural language, using "mountains of information from Wikipedia and encyclopedias, dictionaries, religious texts, novels, plays, and books from Project Gutenberg, among other sources." Watson was also trained to attach a confidence score to its results, and ring in to answer the question when confidence reached a set threshold. In two matches played over three days, Watson achieved a total score of $77, 147, compared to Jennings with $24,000 and Ruter with $21,600. After the match, Jennings commented, "'Quiz show contestant' may be the first job made redundant by Watson, but I'm sure it won't be the last." According to IBM, the major breakthrough was that "Watson's ability to uncover insights in unstructured data represented a big leap in a subset of artificial intelligence called natural language processing and an important step toward a world in which intelligent machines are able to understand and respond to everyday questions to improve decision-making [3].” Since that time, further developments in natural language processing have contributed to the rise of generative AI, that is, artificial intelligence capable of generating new material, rather than retrieving or recreating existing information.

When OpenAI released its chatbot on November 20, 2022, more than a million people tried it within five days, and within two months, it had 100 million active, daily users. Since that time, many generative AI tools have been developed and have been applied to fields ranging from art to medicine, and poetry to finance [1]. Religious groups have even developed AI tools to provide church-related information and advice, such as Cathy, the Episcopal Church’s “virtual guide.” Cathy (Churchy Answers That Help You) was trained on the Episcopal Church’s website, the Book of Common Prayer and Forward Movement publications, and the ChatGPT knowledge base. Suggestions for how this bot is to be used include inquiries on official positions of the Episcopal church, suggestions for liturgy, and general questions about the church and its practices [4].

With such wide-ranging applications, it is reasonable to ask how this technology can be applied to the field of engineering. However, first some background on AI and what constitutes generative AI is necessary.

What is generative AI?

The modern history of GAI dates back to the 1950s—“artificial intelligence” was first introduced as a science in 1956, followed by the development of the perceptron, the first simple system that attempted to model the working of the human brain, in 1958 [5]. Although the capability of the early systems was extremely limited, they laid the groundwork for more complex neural networks developed in the 1980s, after developments in training, such as back-propagation, allowed the application of multi-layered, fully interconnected nets which could handle complex learning tasks. [6]. The development of deep learning in the 2010s significantly improved the capability of neural nets to handle very large data sets. This enhanced the ability of artificial systems to handle tasks such as image classification, speech recognition and natural language processing, which had been handled with limited success by traditional programming techniques. A new deep learning technique, introduced by Ian Goodfellow in 2014, was the development of Generative Adversarial Networks (GANs), in which two neural nets—a generator and a discriminator—compete with each other to produce realistic “human-like images, sounds, music, and text [5].” These advances led to the Large Language Model (LLM) platforms, such as OPEN AI’s GPT, introduced in 2018, which allow the systems to generate new content, rather than organizing and interpreting existing material—hence the name Generative AI, distinguishing it from more traditional artificial intelligence engines. Since that time a multitude of new platforms have been developed on this basis, tailored to such varied applications as robotics, biomedical research, architecture, law and journalism. [5].

What benefits can GAI provide to engineers?

The best-known generative AI tools in general use today and the companies associated with them are Gemini (Google), Claude (Anthropic), ChatGPT (OpenAI/Microsoft) and LLaMA (Meta). In addition to these general purpose tools, there are more focused tools for general research (Quivr, ExplainPaper, scite_, and keenious), coding (GitHub, codium, and tabnine) and scholarly research (consensus, Elicit, and ResearchRabbit) [1]. Using only these tools, engineers could write reports or proposals, take minutes or transcriptions of meetings, create PowerPoints, generate lab assignments, generate code in multiple languages, and even grade student papers. In addition to these more generic tools, there are tools designed for specific engineering tasks, such as, for electrical engineering,

- Cadence Allegro X AI—a tool for PCB design that uses GAI to autonomously generate optimized layouts, routing and component placements, including factors such as reliability, power distribution and thermal issues [7].
- Matlab and Simulink—these familiar engineering programs now include an integrated GAI chat [ ]that "can help users find answers, get initial drafts of code, and help break down complex engineering problems [8]."
- Autodesk Fusion 360—in addition to the ability to its well-known capabilities in 3-D modeling, includes an electronic workplace, and uses generative AI to optimize designs based on user specified objectives [9].
- ChatGrid^{TM}—a GAI tool, developed as part of the Department of Energy's ExaScale Computing Project, that can visualize a portion of the power grid that can answer "questions about generation capacity, voltage, power flow and more, while customizing the visualization to show different information layers [10]."
- And many others.

Regardless of the type of engineering that you are interested in supporting using generative AI, a simple web search will turn up a plethora of candidates.

Does AI live up to the hype?

In order to explore for themselves the capabilities of available generative AI tools, the authors selected four common, generic GAI platforms, Chat GPT, Google Gemini, Microsoft Copilot, and Claude AI, to be tested with eight prompts that might arise in electrical engineering and computer science undergraduate courses. The prompts uses were:

1. Create a study guide that will prepare a student for an exam that covers number systems including binary, octal, decimal, and hexadecimal, and BCD. It should also cover binary signed integers using sign magnitude, 1's complement, and 2's complement formats.
2. Create a set of practice questions that will prepare a student for an exam that covers number systems including binary, octal, decimal, and hexadecimal, and BCD. It should also cover binary signed integers using sign magnitude, 1's complement, and 2's complement formats.
3. Design an operational amplifier adder which will produce a non-inverted sum of two voltage inputs. Your design should have at least two stages, and should amplify the sum by a gain factor between 500 and 800 at DC. Use resistors on the order of 1k to 100k ohms in your design.
4. Design a power converter that accepts an input between 110 volts AC and 130 volts AC, and outputs 5 volts DC. The converter must maintain a 5 volt DC output with a ripple voltage

less than 1 millivolt up to an output current of 1 ampere. The output must be within 100 millivolts of the 5 volt target output, regardless of the load.

5. It is very cold outside (0 degrees Fahrenheit). My car will not start. The starter is turning slowly, but not fast enough to start the engine. The battery is not supplying enough current. What should I do?
6. Write a C++ program that generates an array of 10 random integers between 0 and 1000. The program must sort the values from highest to lowest, and print the sorted array.
7. Write a C++ program for a text-based blackjack game. The program must include a class called Card, and a class called Deck.
8. My client wants me to build a website. They sell fruit including apples, oranges, grapes, and strawberries. They want html code, css code, php code, and sql code. The database must store orders that include customer information, the types and quantities of fruits, the client's inventory, and information about if and when orders are shipped. Write the code to meet my client's needs.

Each prompt was applied to each tool, with the results ranked in Table 1. The standard used for evaluation was based on how the answer would be graded if a student in an appropriate course provided the response:

5 = Great answer. The answer is completely or mostly correct (full credit).
3 = Useful but not correct answer. The answer is flawed, but somewhat correct (partial credit).
1 = Wrong answer or no answer. The answer shows a lack of understanding (no credit).

	Prompt Number							
	1	2	3	4	5	6	7	8
Tool								
Chat GPT	3	1	3	3	1	3	5	3
Google Gemini	3	5	3	4	1	1	3	3
Microsoft Copilot	3	5	3	3	1	3	5	3
Claude AI	5	5	3	4	1	3	5	3

Figure 1. Comparison of AI Tools

The explanation of the table results is summarized below:

Prompt 1: The goal here was an explanation of how to convert between bases that was clear and easy to understand. ChatGPT, Gemini and CoPilot all produced correct information, but presented it in strange characters and formats that made it difficult to understand. For example, from ChatGPT, "Each hexadecimal digit corresponds to four binary digits (e.g., (A_{16} = 1010_2));" from Gemini, "Each digit's position determines its value (e.g., A2F(hex) = 1016^2 + 216^1 + 15*16^0)" and from CoPilot, "1A3 in hexadecimal represents 1×162+10×161+3×160=419 in decimal." The conclusion was that none of these was an acceptable explanation of the process. Claude, however, was completely successful at this task, producing clear and well formatted responses, such as "$2F_{16} = 2\times16^1 + 15\times16^0 = 32 + 15 = 47_{10}$."

Prompt 2: A fully correct response should contain sample questions involving the conversion between all bases and formats, and should be formatted appropriately. Gemini, CoPilot and Claude were all completely successful at this task. Only ChatGPT failed, in that many of the practice questions didn't make sense, and/or there was no understanding of reasonable range; for example: "Convert from binary to...'101101121011011_210110112.'"

Prompt 3: None of the tools produced a usable circuit. Three tools, ChatGPT, CoPilot, and Claude, all violated the restrictions for the sizes of resistors specified in the prompt. Since these were based on internal circuity of the particular operational amplifiers available in the lab, none of these circuits would function as desired. The response by Gemini kept within the resistor restrictions; however, it stated that the second stage would be a voltage follower with gain, but showed a stage with unity gain, so the overall circuit did not meet the required gain by a factor of 50. Each of the circuits looked convincing, but were all incorrect.

Prompt 4: A fully correct response should describe a simple AC/DC converter including a linear regulator design, and values for components. All four tools failed in multiple ways. None of the tools provided values for the components. ChatGPT and CoPilot suggested a switching power converter with a poor design. Only Claude suggested a transformer that might provide reasonable efficiency given the following stages. All four tools suggested a regulator chip, rather than a linear regulator design.

Prompt 5: None of the tools were able to understand the problem. The low temperature has slowed the chemical reaction within the battery, thus increasing the internal resistance. The solution is to increase the battery load, which causes current to flow within the battery. A good solution would be to turn on the headlights, which is counter intuitive. This will raise the battery temperature and decrease the internal resistance. Since this solution is not well represented on-line, the tools lacked the creativity or understanding to solve the problem.

Prompt 6: This classic question asks a student to write a sorting algorithm, without using a predefined sort function. Three of the tools (ChatGPT, CoPilot, and Claude) side-stepped the requirements by using overly complicated and confusing code. Rather than write a simple selection sort, these tools employed a much lengthier and overly complicated approach. Gemini simply stated, "I'm a text-based AI, and that is outside of my capabilities".

Prompt 7. Three of the tools produced successful code: ChatGPT, Claude, and CoPilot. Though Gemini wrote good code, it was incomplete; for example: "// ... (Game logic implementation)". Thus, it was not successful at the task, though overall, this is the prompt on which the tools as a group were most successful.

Prompt 8. The information given in the problem was actually insufficient. On a project such as this, developers must meet with their clients and gather project requirements. A real software developer would understand that the information given is insufficient. However, all four tools performed impressively in that the code they wrote was good, but none recognized that the information given was not sufficient, so none successfully completed the assignment. These results show that human interaction is still necessary for this type of task.

In summary, while some of the tools produced good answers to some of the prompts, they all had inaccuracies that made them unreliable in multiple scenarios, in ways that might not be apparent to those without sufficient experience to accurately judge performance, such as students using the tools uncritically.

What ethical issues arise in use of generative AI?

One of the most potentially serious, and most highly publicized, issues with generative AI is the question of the trustworthiness of information generated. In many cases, the information generated by generative AI is factually incorrect, with recent studies showing an error percentage to open-ended questions ranging from 12.3% to 68% [11]. Given the critical nature of information in engineering, and its implications for public safety, this calls into question its applicability in real world applications. The tendency of these tools to "hallucinate," or include information that is completely incorrect or even nonsensical, is well known, and given the application, can have very serious consequences. For example, a recent AP news article described the use of OpenAI's Whisper transcription tool advertised as having "near 'human level robustness and accuracy'" in hospitals for transcription of medical appointments. The tool had been "fine-tuned on medical language to transcribe and summarize patients' interactions" and "has been used to transcribe an estimated 7 million medical visits." In general, it is not possible to check the accuracy of the transcriptions, as the original recordings are destroyed after the AI tool is applied, for patient privacy [12]. However, a study conducted by researchers from universities including Cornell and the University of Washington found that Whisper transcripts included hallucinations in approximately 1.4% of the transcriptions, of which 40% were judged by the study to have the potential for harm. These included "violent and racially charged" remarks not included in the original text, and fictional medical treatments, such as "hyperactivated antibiotics [13]." As transcriptions of meetings and summaries of material are some of the uses suggested by many for engineers, the potential of LLMs to misinterpret or fabricate information must be an ethical consideration. Also, given the propensity of AI to give unreliable information, any application in engineering makes the ability of engineers to evaluate the AI-generated content and use engineering judgement as to its accuracy critical.

Another ethical issue regarding generative AI currently in the news is the use of copyrighted material to train the AI tools. There are currently a number of lawsuits working their way though the legal system by content creators challenging the unauthorized use of their works in AI training protocols, so the legality of this use has yet to be determined. However, the argument made by the AI companies is that this is fair use of publicly available information. Some of the factors that are likely to be considered by the courts in resolving this issue are

- Purpose and character of the use—"whether the use is a commercial or nonprofit educational use, and whether the work 'transforms' and adds something new to the copyrighted work"
- Nature of the copyrighted work—whether the work is primarily factual or creative
- Amount of the copyrighted work used—whether the whole work is used or "the work's creative 'heart'" is included
- Impact on the market value of the copyrighted—whether the copyrighted work will be less valuable or have a smaller market based on the unauthorized use [14]

While it is likely that it will take years for the courts to resolve the issue of use of copyrighted material, because of the way artificial intelligence is trained, rather than programmed, simply removing copyrighted material from a trained AI system is not possible, so it is not clear what the remedy would be if the lawsuits were decided in favor of the copyrighted content owners. Another related issue is that information input in prompts to generative AI may become part of the training data base, making its use for any sort of classified or proprietary information questionable, from both an ethical and a business perspective.

Environmental impacts must also be considered in the use of generative AI. LLMs use a tremendous amount of computing power to answer even simple questions, and keeping the servers cool enough to function requires a great deal of energy and, for some installations, water for cooling. *The Washington Post*, together with researchers from the University of California, Riverside, conducted a study investigating the environmental cost of OpenAI's ChatGPT-4 released in March 2023. Using the response to a 100-word email as the test, researchers estimated that the water usage of answering a single email once as the equivalent of one 16-ounce bottle of water, and the electricity use as the equivalent of powering 14 LED light bulbs for an hour. Response to a 100-word email once a week for a year brings the usage to the equivalent of the water in 1.43 watercooler jugs and the electricity used by nine DC households for 1.5 hours. This does not include the energy and resources necessary to train the AI engines, but only that used in querying the trained system. Although Google made the commitment to make their systems sustainable, the environmental report released in July 2024 showed that "its carbon emission footprint rose by 48 percent, largely due to AI and data centers. It also replenished only 18 percent of the water it consumed. [15]." Although some regard these environmental impacts as an acceptable cost of doing business, generative AI is straining electrical grids and requiring new capacity in the electrical infrastructure. This is leading to unprecedented moves such as the potential re-opening of the shuttered Three Mile Island nuclear plant to fuel Microsoft data centers. If approved, the plant would provide 835 megawatts, equivalent to the energy required to power 800,000 homes, and would be the first instance of a commercial power facility having a single customer [16].

Another ethical issue much in the news is that of plagiarism. The views on this issue vary widely, ranging from those who would define a "post-plagiarism" era in which in which "advanced technologies, including artificial intelligence and neurotechnology, including brain-computer interfaces (BCIs), are a normal part of life, including how we teach, learn, and interact daily," [17] to distressed academics, trying to find ways to detect unauthorized use of GAI and to come up with assignments that cannot be handled with those tools, but require students to do their own work unassisted [18]. That there is not a consensus on this issue is illustrated by the CEO of Perplexity, a company currently being sued by *Dow Jones* and *The New York Post* for "content kleptocracy," when asked how his company defined "plagiarism," being unable to provide a definition [19]. In the absence of accepted definitions and consensus on what appropriate use of GAI is, both in the classroom and the workplace, care must be used to clearly define in advance what use is acceptable and how it should be cited in a particular instance or application.

Potential effects on jobs and the workplace can also raise ethical issues. Predictions on effects of GAI in the workplace are varied, but few predict that it will have no effect, some comparing it to the combined effect of agricultural and industrial revolutions. [20]. According to the McKinsey report, published in July of 2023, an average of 29.5% of the number of hours currently worked in the US today will be automated by GAI by 2030, including 30% of the work done by STEM professionals. The report predicts that there will still be an increasing demand for STEM workers, but that there will be a "high change of work activities." A significant loss of jobs is predicted for office workers and customer support, [21] which will have an effect on the engineering workplace as we know it. Workers are already concerned about affects on AI on their workplaces. According to a survey of 1,150 U.S. workers in March 2024, "63% expressed fears about AI use and 61% are concerned it will increase burnout. Nearly 90% of young workers fear AI-related burnout and about half of the women surveyed think AI will negatively impact work-life balance. Two-thirds of the respondents are afraid of losing their jobs due to AI [22]."

Many believe that using generative AI will make their work easier. In academia, students embrace the technologies, viewing them "as an enabler, freeing them from the humdrum of rote-learning," and with some professors regarding them as tools that "free them from the 'humdrum' tasks of writing assessment papers, giving them more time for research and curriculum development [23]." However, this could come at a cognitive cost. In a recent study, students were assigned to research an unfamiliar technical topic and make recommendations based on their research. Students were divided in to groups using standard search engines and those using GAI. Results indicated that students using the AI tools had a lower "cognitive burden," that is the necessary "allocation of [the students'] cognitive resources" in multiple facets dedicated to the task, so students perceived the task as easier. However, these students "demonstrated lower-quality reasoning and argumentation in their recommendations" compared to those of the students in the control group. This led researchers to conclude that for this type of assignment, "while the information was easier to process, it might not have engaged the deep learning processes as effectively as the more challenging traditional search tasks [24]." Others hypothesize a variety of cognitive risks from dependence on GAI, including reduced mental engagement, neglect of cognitive skills, loss of memory capacity, attention and focus issues, lack of transferrable knowledge and mental health impacts. While the research on potential cognitive effects of reliance on generative artificial intelligence is in its infancy, sufficient evidence exists to warrant concern, and should be further explored so that those using these tools are aware of all risks involved [25].

Concluding thoughts

Based on our research and our explorations of generative AI tools currently available, the authors conclude that the answer to the question as to whether this technology is a tool or trouble for engineering practice, is "yes" to both. As a tool, generative AI shows great promise as a potential aid for engineers, but it must always be used with caution. As ChatGPT responded to the authors' query about ethical issues in the uses of generative AI in engineering and engineering education, "ChatGPT can generate incorrect or misleading information, especially in complex fields like engineering, where even minor errors can have serious consequences. If AI-generated answers are trusted without verification, faulty designs, calculations, or interpretations could lead to harmful outcomes [26]." Many ethical issues must also be addressed, both regarding the technology as a whole and its use in specific applications. It is our responsibility as engineering educators to ensure that our students develop the technical skills necessary to perform essential engineering tasks, in order to be able to effectively evaluate any work done or enhanced by AI tools, and to develop the engineering judgement necessary to determine when AI tools are appropriate for use. As generative AI becomes more sophisticated and the tasks to which it is applied grow in number and complexity, engineering skills and engineering judgement will become even more critical to the engineering workforce.

References

[1] J. A. Bowen and C. E. Watson, *Teaching with AI,* Baltimore, MD: Johns Hopkins University Press, 2024.

[2] IBM, "Deep Blue," nd [Online]. Available: https://www.ibm.com/history/deep-blue [Accessed November 7, 2024].

[3] IBM, "Watson, 'Jeopardy!' Champion," nd [Online]. Available: https://www.ibm.com/history/watson-jeopardy [Accessed November 7, 2024].

[4] TryTank Research Institute, "Frequently Asked Questions," nd [Online]. Available: https://www.askcathy.ai/faq.html [Accessed November 7, 2024].

[5] H. K. Kılınçand Ö. Fatih Keçecioğlu. "Generative Artificial Intelligence: A Historical and Future Perspective." *Academic Platform Journal of Engineering and Smart Systems* 12, no. 2: 2024. Available: https://dergipark.org.tr/en/pub/apjess/issue/84800/1398155. [Accessed November 12, 2024].

[6] D. Dasgupta , D. Venugopal and K. D. Gupta, "A Review of Generative AI from Historical Perspectives" *TechRxiv,* February 17, 2023. DOI: 10.36227/techrxiv.22097942.v1. [Accessed November 12, 2024].

[7] Cadence, "Allegro X Design Platform Datasheet," [Online] Available: https://www.cadence.com/en_US/home/resources/datasheets/allegro-x-design-platform-ds.html. [Accessed November 12, 2024].

[8] H. Scharler, "The MATLAB AI Chat Playground Has Launched," MathWorks, November 7, 2023. [Online] Available: https://blogs.mathworks.com/community/2023/11/07/the-matlab-ai-chat-playground-has-launched/. [Accessed November 12, 2024].

[9] E. Robledo, "Powering Your Products: Autodesk Fusion 360 Electronics Highlights You Don't Want to Miss," Autodesk, September 7, 2023. [Online] Available: https://www.autodesk.com/products/fusion-360/blog/autodesk-fusion-360-electronics-highlights/. [Accessed November 12, 2024].

[10] J. Wendel, "ChatGrid™: A New Generative AI Tool for Power Grid Visualization," Pacific Northwest National Laboratory, February 22, 2024. [Online] Available: https://www.pnnl.gov/news-media/chatgridtm-new-generative-ai-tool-power-grid-visualization. [Accessed November 12, 2024].

[11] Y. Wang, M. Wang, M. A. Manzoor, F. Liu, G. Georgiev, R. J. Das, and P. Nakov. "Factuality of large language models in the year 2024." *arXiv preprint arXiv:2402.02420* (2024).

[12] G. Burke and H. Schellmann, "Researchers say an AI-powered transcription tool used in hospitals invents things no one ever said," AP News, October 26, 2024, [Online] Available: https://apnews.com/article/ai-artificial-intelligence-health-business-90020cdf5fa16c79ca2e5b6c4c9bbb14. [Accessed November 10, 2024].

[13] G. Swain, "Patients may suffer from hallucinations of AI medical transcription tools," *CIO,* IDG Communications, October 28, 2024, [Online] Available: https://www.cio.com/article/3593403/patients-may-suffer-from-hallucinations-of-ai-medical-transcription-tools.html. [Accessed November 10, 2024].

[14] C. Coffman, "Does the Use of Copyrighted Works to Train AI Qualify as a Fair Use?" Copyright Alliance, April 11, 2023 [Online] Available: https://copyrightalliance.org/copyrighted-works-training-ai-fair-use/. [Accessed November 10, 2024].

[15] P. Verma and S. Tan, "A bottle of water per email: the hidden environmental costs of using AI chatbots" Washington Post, September 18, 2024 [Online] Available: https://www.washingtonpost.com/technology/2024/09/18/energy-ai-use-electricity-water-data-centers/ [Accessed September 20, 2024.]

[16] E. Halper, "Microsoft deal would reopen Three Mile Island nuclear plant to power AI," Washington Post, September 20, 2024 [Online] Available: https://www.washingtonpost.com/business/2024/09/20/microsoft-three-mile-island-nuclear-constellation/. [Accessed November 10, 2024].

[17] S. E. Eaton, "Postplagiarism: transdisciplinary ethics and integrity in the age of artificial intelligence and neurotechnology" (editorial), *International Journal for Academic Integrity*, vol. 19 23 (2023) [Online] Available: https://edintegrity.biomedcentral.com/articles/10.1007/s40979-023-00144-1. [Accessed November 11, 2024].

[18] B. McMurtrie, "Cheating has become normal," *Chronicle of Higher Education,* November 4, 2024, [Online] Available: https://www.chronicle.com/article/cheating-has-become-normal. [Accessed November 12, 2024].

[19] K. Wiggers, "Perplexity's CEO punts on defining 'plagiarism.'" TechCrunch, October 10, 2024. [Online] Available: https://techcrunch.com/2024/10/30/perplexitys-ceo-punts-on-defining-plagiarism/. [Accessed November 12, 2024].

[20] Q. Hamirani. "Here's how Generative AI will redefine the workplace," *Forbes,* February 15, 2024. [Online] Available: https://www.forbes.com/sites/qhamirani/2024/02/15/heres-how-generative-ai-will-redefine-the-workplace/ [Accessed November 11, 2024].

[21] K. Ellingrud, *et al., Generative AI and the future of work in America,* McKenzie Global Institute, July 20, 2023, [Online] Available: https://www.mckinsey.com/mgi/our-research/generative-ai-and-the-future-of-work-in-america#/. [Accessed November 12, 2024].

[22] B. Violino, "Yes, AI burnout is already happening at work. Here's how to prevent it" MSNBC, August 16, 2024 [Online] Available: https://www.cnbc.com/2024/08/16/ai-burnout-workers.html. [Accessed November 12, 2024].

[23] W. K. O. Wong, “The sudden disruptive rise of generative artificial intelligence? An evaluation of their impact on higher education and the global workplace,” *Journal of Open Innovation: Technology, Market, and Complexity*, Volume 10, Issue 2, 2024, 100278, ISSN 2199-8531, Available: https://www.sciencedirect.com/science/article/pii/S2199853124000726?via%3Dihub [Accessed November 11, 2024].

[24] M. Stadler, M. Bannert and M. Sailer, “Cognitive Ease at a cost: LLMs reduce mental effort but compromise depth in student scientific inquiry,” *Computer in Human Behavior,* Volume 160, 2024, 108386, ISSN 0747-5632. Available: https://www.sciencedirect.com/science/article/pii/S0747563224002541). [Accessed November 11, 2024].

[25] I. Dergaa, *et al.* “From tools to threats: a reflection on the impact of artificial-intelligence chatbots on cognitive health” *Frontiers in psychology*, vol. 15 1259845, April 2, 2024. Available: https://doi.org/10.3389/fpsyg.2024.1259845 [Accessed November 11, 2024].

[26] OpenAI, ChatGPT response to query regarding ethical issues of generative AI use in engineering fields, https://chatgpt.com/, [Accessed September 17, 2024.]