



The ChatGPT Dilemma: Opportunities vs. Risks in Engineering Education

Ramiz Assaf^{1,*}, Amjad El-Qanni¹, Ihab H. Alsurakji¹ &

Mahmoud Assad¹

Received: 5th Nov. 2023, Accepted: 20th Feb. 2024, Published: 1st Oct. 2024

DOI: [10.35552/0247.38.10.2285](https://doi.org/10.35552/0247.38.10.2285)

ABSTRACT

Objective: This research aims at exploring ChatGPT's features and benefits in engineering education, while presenting suggested best practices, potential challenges, and ethical considerations for its use in this field. **Methodology:** Descriptive analysis of ChatGPT applications in engineering education, focusing on benefits, challenges, and limitations. **Key Findings:** ChatGPT has diverse applications across various domains, with unprecedented attention in media, industry, and academia. ChatGPT can help enhance students' problem-solving and soft skills (21st century skills). There is a need to change the teaching and assignment approach in engineering to better harness ChatGPT's capabilities. **Conclusions:** Educators in the engineering field should emphasize the importance of addressing the limitations of Generative AI-based tools to fully harness their benefits. The use of ChatGPT in engineering education presents benefits, challenges, and limitations that must be considered. **Recommendations:** Adapt teaching methods in engineering to align with ChatGPT's capabilities. Develop strategies to address ethical and practical challenges associated with using ChatGPT in engineering education. Conduct further research to evaluate ChatGPT's impact on learning outcomes and skill development in engineering education.

Keywords: ChatGPT, Engineering Education, Artificial intelligence (AI), Generative AI, Pre-training Transformer.

¹ Industrial and Mechanical Engineering Department, Faculty of Engineering & Information Technology. An-Najah National University, P.O. Box 7, Nablus, Palestine

*Corresponding author: ramizassaf@najah.edu

معضلة ChatGPT: التوازن بين الفرص والمخاطر في التعليم الهندسي رامز عساف^{1*}، وأمجد القني¹، وإيهاب السركجي¹، ومحمود أسعد¹

تاريخ التسليم: (2023/11/5)، تاريخ القبول: (2024/2/20)، تاريخ النشر: (2024/10/1)

ملخص

الهدف: هدفت هذه الدراسة لاستكشاف ميزات ChatGPT وفوائده في مجال التعليم الهندسي، مع تقديم أفضل الممارسات المقترحة والتحديات المحتملة والاعتبارات الأخلاقية لاستخدامه في هذا المجال. **المنهج:** تحليل وصفي لتطبيقات ChatGPT في التعليم الهندسي، مع التركيز على الفوائد والتحديات والقيود. **النتائج:** ChatGPT له تطبيقات متنوعة في مجالات مختلفة، مع اهتمام غير مسبوق في وسائل الإعلام والصناعة والأوساط الأكاديمية. يمكن لـ ChatGPT المساعدة في تعزيز مهارات حل المشكلات والمهارات الناعمة (مهارات القرن الحادي والعشرين) لدى الطلاب. هناك حاجة لتغيير نهج التدريس والواجبات الأكاديمية في مجال الهندسة لاستغلال إمكانيات ChatGPT بشكل أفضل. **الاستنتاجات:** يجب على المعلمين في مجال الهندسة التأكيد على أهمية معالجة قيود الأدوات القائمة على الذكاء الاصطناعي التوليدي للاستفادة الكاملة من فوائدها. أيضاً استخدام ChatGPT في التعليم الهندسي يقدم فوائد وتحديات وقيوداً يجب أخذها في الاعتبار. **التوصيات:** ضرورة تكييف الأساليب التعليمية في مجال الهندسة لتتناسب مع قدرات ChatGPT وتطوير استراتيجيات لمواجهة التحديات الأخلاقية والعملية المرتبطة باستخدام ChatGPT في التعليم الهندسي. بالإضافة لإجراء المزيد من البحوث لتقييم تأثير ChatGPT على نتائج التعلم وتطوير المهارات في مجال التعليم الهندسي.

الكلمات المفتاحية: ChatGPT، التعليم الهندسي، الذكاء الاصطناعي، الذكاء الاصطناعي التوليدي.

1 دائرة الهندسة الصناعية والميكانيكية، كلية الهندسة وتكنولوجيا المعلومات، جامعة النجاح الوطنية، نابلس، فلسطين
*الباحث المراسل: ramizassaf@najah.edu

Introduction

ChatGPT is a Natural Language Processing (NLP) model developed by OpenAI that is designed to have conversations with humans. It is an extension of the popular GPT (Generative Pre-training Transformer) language model, which is trained to generate human-like text by predicting the next word in a given sequence (Lund & Wang, 2023; Lund et al., 2023). ChatGPT uses a type of NLP called "transformer" architecture, which is a type of neural network that is designed to process and generate language. One of the key features of transformer architecture is that it allows the model to maintain a "context" of previous inputs (Qin et al., 2023). ChatGPT is considered a game changer in NLP due to its ability to generate natural and contextually relevant responses that are indistinguishable from those of a human (Floridi, 2023). ChatGPT has several implications for various NLP applications, such as chatbots, automated writing and content creation, AI art generator and language understanding for AI applications.

Artificial intelligence (AI) is a field of study and the resulting innovations and developments that have culminated in computers, machines, and other artifacts having human-like intelligence characterized by cognitive abilities, learning, adaptability, and decision-making capabilities (Chen, Chen, & Lin, 2020). AI is increasingly being integrated into engineering curricula to prepare students for a world where machines are increasingly used to solve complex problems (Akgun & Greenhow, 2022). AI can enhance and transform engineering education in various ways, such as: Personalizing and adapting learning experiences for students based on their needs, preferences, and performance (Cui, Xue, & Thai, 2018). Creating intelligent textbooks ("knowledge behind pages") that generate interactive content, feedback, and self-assessment (Brusilovsky, Sosnovsky, & Thaker, 2022). Developing computational thinking and problem-solving skills with generative AI and LLMs that create realistic scenarios, data sets, and solutions (Lund et al., 2023). Integrating interdisciplinary and cross-cultural perspectives with AI-based chatbots that simulate dialogues with experts and peers from different backgrounds (Demir, 2023). Enhancing assessment and evaluation of

learning outcomes and competencies with AI-based tools that provide automated grading, feedback, and analytics.

Relevance to higher education in engineering

In recent years, AI-based tools like ChatGPT have shown great potential in revolutionizing engineering education. However, to fully leverage the benefits of such tools, it is crucial to use them carefully and responsibly. As a powerful and promising tool in engineering education, ChatGPT requires careful consideration of the opportunities and challenges it presents. Engineering educators should be knowledgeable about ChatGPT and adopt strategies to ensure its ethical and effective use. Table 1 shows a summary of the benefits / challenges to be considered when integrating ChatGPT into education more specifically in Engineering Education. ChatGPT and/or similar technologies are relevant to engineering education for a number of reasons; It can enhance student engagement by providing interactive and personalized feedback, guidance, and support. It can also stimulate curiosity and motivation by generating challenging and relevant questions, scenarios, and problems (Cotton, Cotton, & Shipway, 2023; Fergus, Botha, & Ostovar, 2023). It can also foster peer learning and feedback by generating group discussions and activities (Cotton et al., 2023; Hwang & Chang, 2023). ChatGPT can improve accessibility by offering multilingual and multimodal options for students with diverse backgrounds, preferences, and needs. It can also adapt to different learning styles and paces by providing customized and differentiated instructions (Hwang & Chang, 2023; Zhai, 2022). Also, ChatGPT can assist with research and design tasks by generating novel and creative ideas, solutions, and prototypes. It can also help with data analysis, literature review, and report writing by summarizing, synthesizing, and citing relevant information (Fergus et al., 2023; Hwang & Chang, 2023).

Herein, we used a methodical process to choose and compile pertinent articles about ChatGPT's advantages for engineering education. We utilized databases and search engines to find relevant literature, utilizing keywords such as "ChatGPT," "engineering education," and "benefits." We used peer-reviewed and empirical articles as the basis for inclusion

and exclusion criteria, which helped us to narrow down the choices. After gathering data from the chosen publications, we combined the findings into recurring themes and arranged them to present a thorough summary of the advantages mentioned in the literature. Our study's validity and trustworthiness are guaranteed by our open and meticulous methodology, which also makes a significant contribution to the field of engineering education. Such a rigorous approach ensures the robustness and reliability of the insights presented in our study.

Strategies and techniques of ChatGPT usage

Developing policies and procedures to regulate the use of ChatGPT and prevent academic dishonesty [10]. Providing training and support to students and teachers on how to use ChatGPT appropriately and critically (Chen et al., 2020; Fergus et al., 2023). Using various methods to detect and prevent cheating, such as plagiarism detection software, proctoring tools, or human verification (Atlas, 2023; Cotton et al., 2023). Designing assessments that are authentic, both open/closed ended, and aligned with learning outcomes (Cotton et al., 2023; Zhai, 2022). Evaluating the quality and validity of the machine-generated texts using rubrics, criteria, or feedback (Cotton et al., 2023). Encouraging human interaction and collaboration among students and teachers using ChatGPT as a supplement or a catalyst (Fergus et al., 2023; Qadir, 2023).

Addressing ethical and legal issues related to the use of ChatGPT by following codes of conduct, guidelines, or regulations (Cooper, 2023; Lund et al., 2023). ChatGPT is relevant to engineering education since it can offer various benefits for learning and teaching. However, it also presents some challenges and risks that need to be addressed. Engineering educators should be aware of these issues and adopt strategies to ensure the ethical and effective use of ChatGPT.

Table (1): ChatGPT Benefits.

Benefit	Ref.
ChatGPT can generate responses that are tailored to the level, progress, and needs of each student. It can also give constructive and timely feedback that can help students improve their learning outcomes.	(Fergus et al., 2023)
ChatGPT can offer multilingual options that can translate, explain, or simplify technical terms and concepts. ChatGPT can also help students develop their language skills by providing practice and correction.	(Lund et al., 2023) (Zhai, 2022) (Vyawahare & Chakradeo, 2020)
ChatGPT can generate examples, analogies, or diagrams that can illustrate and clarify complex technical concepts. It can also answer questions and provide hints or suggestions that can help students solve problems.	(Qadir, 2023)
ChatGPT can generate novel and diverse ideas, solutions, and prototypes. It can also help students explore different perspectives and scenarios by generating alternative or counterfactual outcomes.	(Zhai, 2022)
ChatGPT can generate challenging and relevant questions, problems, and cases. It can also help students evaluate and justify their arguments and decisions by generating evidence, criteria, or feedback.	(Cotton et al., 2023)
ChatGPT can also help students reflect on their learning and performance by generating self-assessment, feedback, or goals.	(Zhai, 2022) (Naumova, 2023)
ChatGPT can be a valuable tool for enhancing students' research potential and boosting productivity, ultimately leading to the production of high-quality research.	(Khlaif et al., 2023)

Challenges and limitations of using ChatGPT

The following are some of the potential challenges and limitations of using ChatGPT in engineering education:

ChatGPT may not always provide accurate or helpful responses what is sometimes referred as “Reliability issues”. This mainly applies for questions that require application of knowledge and interpretation of non-text information, such as graphs, tables, or diagrams. Or questions that have purposely useless extra information. It may also produce inaccurate or misleading information that may confuse or misinform students (Fergus et al., 2023; Mogali, 2024; Sánchez-Ruiz, Moll-López, Nuñez-Pérez, Moraño-Fernández, & Vega-Fleitas, 2023).

ChatGPT may compromise academic integrity by enabling students to cheat or plagiarize from the machine-generated texts. It may also generate texts that are similar to existing sources, making it difficult to detect and prevent plagiarism (Liebrenz, Schleifer, Buadze, Bhugra, & Smith, 2023; Qadir, 2023). ChatGPT may perpetuate biases and stereotypes by generating texts that reflect the biases and stereotypes present in the training data. It may also generate texts that are or individuals (Liebrenz et al., 2023; Lund et al., 2023; Zhuo, Huang, Chen, & Xing, 2023).

ChatGPT may reduce human interaction by replacing or reducing the role of teachers, tutors, or mentors. It may also affect the social and emotional aspects of learning by lacking empathy, humor, or personality (Fergus et al., 2023; Vyawahare & Chakradeo, 2020). ChatGPT may raise ethical and legal issues by violating privacy, security, or intellectual property rights. It may also generate texts that violate academic or professional standards (Vyawahare & Chakradeo, 2020).

Best practices for educators in using AI tools in engineering education

Selecting appropriate AI tools

Educators must take their learning objectives into account when choosing AI technologies to utilize in engineering education. To make sure they are choosing the right tool for their unique learning goals, educators should assess each tool's capabilities, strengths, and limits (Nikolic et al.,

2023; Owoc, Sawicka, & Weichbroth, 2021; Van den Beemt et al., 2020; Vyawahare & Chakradeo, 2020). Examining the particular activities or abilities that the tool is intended to assist with is one method to make sure that AI tools are in line with learning objectives. A program like Google's Dialogflow or IBM's Watson Language Translator, for instance, may be ideal if the learning aim is for students to build their abilities in natural language processing (Maher, Kayte, & Nimbhore, 2020). Instead, a Python libraries like TensorFlow or Scikit-learn could be more suited if the goal is to teach students about machine learning techniques (Maher et al., 2020). However, it is crucial to consider the complexity of the AI tool and whether it corresponds with the comprehension level of the students. A tool that is too easy could not push students sufficiently, while one that is too complicated might deter students from using it. As a result, instructors should select AI technologies that successfully balance complexity and usability. Consequently, when choosing AI technology, educators should think about its ethical consequences. They should assess if the tool upholds moral principles and encourages diversity as well as inclusion. This will guarantee that the AI tool supports ethical technology usage and is consistent with the principles of engineering education (Hagendorff, 2020).

Integrating AI tools into existing teaching methodologies

Engineering students' learning can be improved by incorporating AI technologies into current teaching techniques, especially in the era of ChatGPT (Qadir, 2023). To avoid interfering with the learning process, educators should work to effortlessly integrate AI technologies into their existing curricula. This may be done by figuring out how AI technologies can complement current teaching techniques in certain areas. Integrating AI technologies into problem-based learning activities is a successful way to do so. Students might, for instance, study data sets and forecast and visualize engineering-related issues using machine learning methods (Hajibabae, Pourkamali-Anaraki, & Hariri-Ardebili, 2021). Along with improving students' technical abilities, this kind of practice encourages critical thinking and problem-solving abilities. Using AI technologies to promote student collaboration and communication is another successful

strategy. Teachers can utilize virtual assistants to give students access to information and help around the clock or use natural language processing techniques to support student communication. Hence, the success of AI technologies should be assessed by educators, and they should adapt their teaching strategies as necessary. This necessitates a regular evaluation of students' learning results and their input.

To improve students' comprehension and application of knowledge, experiential learning places a strong emphasis on practical, real-world experiences. Teachers can enhance student engagement and the learning process even further by incorporating AI tools into experiential learning. For instance, students might build and test a bridge structure as part of an experiential learning exercise in civil or mechanical engineering classes. Students can investigate a variety of options and evaluate their structural soundness by using AI techniques to model the behavior and performance of various bridge designs. Through this combination, students' critical thinking and problem-solving abilities are developed in addition to their grasp of engineering principles.

Moreover, throughout the experiential learning exercise, AI systems can offer real-time feedback. AI systems can evaluate the data collected when students test their bridge designs, pinpoint their advantages and disadvantages, and make recommendations for enhancements. Students can refine their designs and make wise judgments thanks to this instant feedback, which encourages greater involvement with the learning process.

Providing proper training and support for both students and educators

While utilizing AI tools in engineering education, it is crucial to offer appropriate training and assistance. To accomplish learning objectives, both instructors and students need instruction on how to utilize the tools successfully. Instructors should have access to professional development opportunities where they may learn about the most recent AI technologies and instructional techniques that use them (Hajibabae et al., 2021). To ensure that instructors are skilled in utilizing the tools, this training should involve hands-on practice. Similarly, students should receive training on

how to use AI tools safely and ethically (Liebrenz et al., 2023). Instruction on how to utilize the tools to solve engineering issues and how to understand the findings they create should be part of this training. In addition to training, it's essential to offer instructors and students continual assistance. Access to technical help, user manuals, and tutorials are some examples of this support. To successfully incorporate AI technologies into their teaching approaches, educators need also to have access to a network of peers who can provide advice and assistance. Furthermore, it is critical to make sure that all instructional and support resources are usable by students with impairments. This involves making content available in different formats and ensuring that the tools are accessible.

Evaluating the effectiveness of AI tools

While a crucial component of utilizing AI technologies in engineering education is regularly assessing their efficacy. This enables teachers to assess if the resources are producing the intended learning results and, if necessary, alter their teaching strategies. Using data analytics to monitor students' achievement and their learning outcomes is a useful method for assessing the efficacy of AI solutions (Alam, 2022). AI tools may be used by educators to examine student data and assess if the tools are assisting students in meeting their learning goals. This strategy gives instructors insightful information on how well students are learning and enables them to immediately change their instructional strategies. Getting student feedback on their use of the AI technologies is another successful strategy. Surveys or focus groups that collect this input might offer insightful information about how students are utilizing the resources and if they find them useful. In addition, the ethical concerns of using AI technologies into teaching approaches should also be considered by educators. They should check that the resources they use uphold moral principles and encourage tolerance and diversity. Finally, it is vital to determine if integrating AI technologies in engineering education is cost-effective. This entails evaluating the expenses related to putting the instruments into use and keeping them up to date and contrasting them with the advantages they offer.

Theoretical and practical implications

Our review of ChatGPT's advantages for engineering education adds to the body of current information and theoretical frameworks. We emphasize how ChatGPT can improve soft skills and problem-solving abilities in line with the framework for 21st-century capabilities. To secure the proper use of AI technology in education, we also stress the significance of resolving constraints, such as biases and ethical problems. Practically speaking, our outcomes guide engineering educators. ChatGPT can be used in conjunction with instructional design to produce interactive problem-solving exercises, virtual tutoring, and personalized learning experiences. Through the use of a learner-centered pedagogical approach, educators can utilize ChatGPT to promote critical thinking, active involvement, and teamwork while offering customized feedback. To improve pedagogical practices and AI literacy and help educators successfully use ChatGPT in the curriculum, we advise continuing professional development. When using ChatGPT in engineering education, it is crucial to properly engineer the prompts. Well-thought-out prompts have a big impact on how engaged students are and how well ChatGPT produces their responses. Instructors ought to concentrate on developing writing prompts that promote critical thinking, problem-solving, and a more thorough comprehension of engineering principles. They can make the most of ChatGPT's potential as a tool for fostering engaging and interesting learning opportunities in engineering education by carefully crafting their prompts.

Ethical considerations in AI-based engineering education

ChatGPT is currently a cutting-edge language model chatbot in the world. It stands apart from other chatbots due to its ability to generate impressive conversation in mere seconds which is impossible to distinguish from a text produced by human writers. Also, it has a unique way of interacting and engaging with users in a way that feels intuitive and natural. ChatGPT is creating significant excitement and concerns about its potential uses for teaching, learning, and assessment in education and various other areas. Despite its impressive capabilities but still flawed and even generates false information and/or reinforces biases. ChatGPT

depends on the quality of its database, therefore when used in education, there are ethical concerns to consider including potential student misuse and the possibility of human job displacement.

Thus, a surge enactment of ethics education is mandatory to improve the effectiveness of ChatGPT usage. Therefore, some of the published research appears to have a neutral stance on ChatGPT, presenting both its strengths and limitations (Akgun & Greenhow, 2022; Mhlanga, 2023; Rudolph, Tan, & Tan, 2023) while other research is in favor of incorporating ethics education into ChatGPT (Borenstein & Howard, 2021; Goldsmith et al., 2020; Khlaif et al., 2023; Qadir, 2023). However, the existing literature provides little guidance and a limited number of studies focusing on supporting engineering students' and teachers' understanding of AI's social, cultural, and ethical implications. Therefore, it argues for a more descriptive approach to ethical challenges and dilemmas of using ChatGPT and other chatbots in education. And analyses their opportunities and threats, and proposes the development of assessment tools to measure descriptive ethical thinking about them.

On one hand, it is crucial for educators to provide guidance and resources to ensure students can use technology responsibly. On the other hand, students can learn how to use technology responsibly, productively, and even effectively (Borenstein & Howard, 2021). Also, they can develop their soft skills, such as communication, teamworking, critical thinking, problem-solving, and communication skills, which are important for their personal and professional lives. Qadir (Qadir, 2023) proposed one an approach to incorporating ChatGPT in education by teaching students about the ethical considerations involved in its use, such as; citing sources, avoiding plagiarism, avoiding overreliance, and avoiding inequalities by developing, e.g., soft skills. Also, he emphasizes that it is necessary to use ChatGPT and other AI chatbots with caution and establish fair usage guidelines and standards since ChatGPT is suffering from limitations and can generate inaccurate information. On the same line, Akgun and Greenhow (Akgun & Greenhow, 2022) present limitations, strengths, and potential advantages of AI chatbots in supporting both students' learning

experiences and teachers' practices and the negative ethical implications of these chatbots.

For engineering education, it is evident that ChatGPT will eventually become a part of it, and as a result, evaluation methods will need to change in order to prevent unethical actions while still being effective. However, it is worth mentioning that while ChatGPT can offer help, it is not a substitute for a human instructor and may not be able to offer the same customized support. Therefore, futuristic efforts will be focused on creating a reliable assessment tool that offers solid proof of validity to insure the accurate interpretation and utilization of such a tool. Therefore, this article is in favor of ethics education in AI and promotes the creation of trustworthy assessment tools that can measure ethical reasoning abilities in engineering contexts.

As an example, students may be given a topic to write an argument supporting a specific ethical position in an ethics class. Without using AI mainly ChatGPT, one group of students would finish the assignment using only their own critical thinking and ethical reasoning abilities. An AI-powered tool would be used by a different group of students to produce an ethics argument on the same subject. Instructors and students can investigate the differences between AI-generated and human-generated arguments in terms of reasoning, views, and subtleties by contrasting the two sets of arguments. They can discuss as a group the advantages and disadvantages of using AI tools to make moral decisions and think about the ramifications for society, including possible biases or the simplicity of difficult moral dilemmas. Such a scenario encourages critical thinking, fosters discussions on the role of AI in ethical decision-making processes, and raises awareness about the ethical considerations associated with using AI tools in education.

Conclusions and future work

ChatGPT is a natural language processing capability that makes it a valuable tool for engineering education. It can be used to create interactive virtual assistants, analyze complex data, develop intelligent tutoring systems, and improve students' communication skills. These applications

have the potential to enhance student learning outcomes and facilitate collaboration among researchers and students. As a conclusion, the use of ChatGPT in engineering education has both potential benefits and challenges that need to be carefully considered. It is important for educators and developers to address these limitations and overcome them in order to maximize the benefits of using AI-based tools like ChatGPT in engineering education.

It is important to include and integrate AI tools in engineering education using different approaches. ChatGPT may incorporate into the teaching methods and to investigate the impact of using AI tools into student skills.

***Availability of data and materials:** The raw data required to reproduce these findings are available in the body and illustrations of this manuscript.

***Author's contribution:** All authors wrote, edited and revised the manuscript and approved its final version.

***Funding:** Not applicable.

***Acknowledgements:** The authors would like to thank the faculty of Engineering and Information Technology at An-Najah National University.

References

- Akgun, S., & Greenhow, C. (2022). Artificial intelligence in education: Addressing ethical challenges in K-12 settings. *AI and Ethics*, 2(3), 431-440. doi: 10.1007/s43681-021-00096-7.
- Alam, A. (2022, 2022//). *Employing Adaptive Learning and Intelligent Tutoring Robots for Virtual Classrooms and Smart Campuses: Reforming Education in the Age of Artificial Intelligence*. Paper presented at the Advanced Computing and Intelligent Technologies, Singapore.
- Atlas, S. (2023). ChatGPT for higher education and professional development: A guide to conversational AI.

- Borenstein, J., & Howard, A. (2021). Emerging challenges in AI and the need for AI ethics education. *AI and Ethics*, 1(1), 61-65. doi: 10.1007/s43681-020-00002-7.
- Brusilovsky, P., Sosnovsky, S., & Thaker, K. (2022). The return of intelligent textbooks. *AI Magazine*, 43(3), 337-340. doi: <https://doi.org/10.1002/aaai.12061>.
- Chen, L., Chen, P., & Lin, Z. (2020). Artificial Intelligence in Education: A Review. *IEEE Access*, 8, 75264-75278. doi: 10.1109/ACCESS.2020.2988510.
- Cooper, G. (2023). Examining Science Education in ChatGPT: An Exploratory Study of Generative Artificial Intelligence. *Journal of Science Education and Technology*, 32(3), 444-452. doi: 10.1007/s10956-023-10039-y.
- Cotton, D. R. E., Cotton, P. A., & Shipway, J. R. (2023). Chatting and cheating: Ensuring academic integrity in the era of ChatGPT. *Innovations in Education and Teaching International*, 1-12. doi: 10.1080/14703297.2023.2190148.
- Cui, W., Xue, Z., & Thai, K. P. (2018, 30 Nov.-2 Dec. 2018). *Performance Comparison of an AI-Based Adaptive Learning System in China*. Paper presented at the 2018 Chinese Automation Congress (CAC).
- Demir, Y. Y. (2023). Human Touch To Artificial Intelligence EFL/ELT Lesson Plans in Education & Science. *Serpil UCAR*, pp. 51–70.
- Fergus, S., Botha, M., & Ostovar, M. (2023). Evaluating Academic Answers Generated Using ChatGPT. *Journal of Chemical Education*, 100(4), 1672-1675. doi: 10.1021/acs.jchemed.3c00087.
- Floridi, L. (2023). AI as Agency Without Intelligence: on ChatGPT, Large Language Models, and Other Generative Models. *Philosophy & Technology*, 36(1), 15. doi: 10.1007/s13347-023-00621-y.

- Goldsmith, J., Burton, E., Dueber, D. M., Goldstein, B., Sampson, S., & Toland, M. D. (2020). *Assessing ethical thinking about AI*. Paper presented at the Proceedings of the AAAI Conference on Artificial Intelligence.
- Hagendorff, T. (2020). The Ethics of AI Ethics: An Evaluation of Guidelines. *Minds and Machines*, 30(1), 99-120. doi: 10.1007/s11023-020-09517-8.
- Hajibabae, P., Pourkamali-Anaraki, F., & Hariri-Ardebili, M. A. (2021, 13-16 Dec. 2021). *An Empirical Evaluation of the t-SNE Algorithm for Data Visualization in Structural Engineering*. Paper presented at the 2021 20th IEEE International Conference on Machine Learning and Applications (ICMLA).
- Hwang, G.-J., & Chang, C.-Y. (2023). A review of opportunities and challenges of chatbots in education. *Interactive Learning Environments*, 31(7), 4099-4112. doi: 10.1080/10494820.2021.1952615.
- Khlaif, Z. N., Mousa, A., Hattab, M. K., Itmazi, J., Hassan, A. A., Sanmugam, M., & Ayyoub, A. (2023). The Potential and Concerns of Using AI in Scientific Research: ChatGPT Performance Evaluation. *JMIR Med Educ*, 9, e47049. doi: 10.2196/47049.
- Liebrez, M., Schleifer, R., Buadze, A., Bhugra, D., & Smith, A. (2023). Generating scholarly content with ChatGPT: ethical challenges for medical publishing. *The Lancet Digital Health*, 5(3), e105-e106.
- Lund, B. D., & Wang, T. (2023). Chatting about ChatGPT: how may AI and GPT impact academia and libraries? *Library Hi Tech News*, 40(3), 26-29. doi: 10.1108/LHTN-01-2023-0009.
- Lund, B. D., Wang, T., Mannuru, N. R., Nie, B., Shimray, S., & Wang, Z. (2023). ChatGPT and a new academic reality: Artificial Intelligence-written research papers and the ethics of the large language models in scholarly publishing. *Journal of the Association*

for Information Science and Technology, 74(5), 570-581. doi: <https://doi.org/10.1002/asi.24750>.

- Maher, S., Kayte, S., & Nimbhore, S. (2020). Chatbots & its techniques using AI: an review. *International Journal for Research in Applied Science and Engineering Technology*, 8(12), 503-508.
- Mhlanga, D. (2023). Open AI in education, the responsible and ethical use of ChatGPT towards lifelong learning. *Education, the Responsible and Ethical Use of ChatGPT Towards Lifelong Learning (February 11, 2023)*.
- Mogali, S. R. (2024). Initial impressions of ChatGPT for anatomy education. *Anatomical Sciences Education*, 17(2), 444-447. doi: <https://doi.org/10.1002/ase.2261>.
- Naumova, E. N. (2023). A mistake-find exercise: a teacher's tool to engage with information innovations, ChatGPT, and their analogs. *Journal of Public Health Policy*, 44(2), 173-178. doi: 10.1057/s41271-023-00400-1.
- Nikolic, S., Daniel, S., Haque, R., Belkina, M., Hassan, G. M., Grundy, S., . . . Sandison, C. (2023). ChatGPT versus engineering education assessment: a multidisciplinary and multi-institutional benchmarking and analysis of this generative artificial intelligence tool to investigate assessment integrity. *European Journal of Engineering Education*, 48(4), 559-614. doi: 10.1080/03043797.2023.2213169.
- Owoc, M. L., Sawicka, A., & Weichbroth, P. (2021, 2021//). *Artificial Intelligence Technologies in Education: Benefits, Challenges and Strategies of Implementation*. Paper presented at the Artificial Intelligence for Knowledge Management, Cham.
- Qadir, J. (2023, 1-4 May 2023). *Engineering Education in the Era of ChatGPT: Promise and Pitfalls of Generative AI for Education*. Paper presented at the 2023 IEEE Global Engineering Education Conference (EDUCON).

- Qin, C., Zhang, A., Zhang, Z., Chen, J., Yasunaga, M., & Yang, D. (2023). Is ChatGPT a general-purpose natural language processing task solver? *arXiv preprint arXiv:2302.06476*.
- Rudolph, J., Tan, S., & Tan, S. (2023). ChatGPT: Bullshit spewer or the end of traditional assessments in higher education? *Journal of Applied Learning and Teaching*, 6(1).
- Sánchez-Ruiz, L. M., Moll-López, S., Nuñez-Pérez, A., Moraño-Fernández, J. A., & Vega-Fleitas, E. (2023). ChatGPT Challenges Blended Learning Methodologies in Engineering Education: A Case Study in Mathematics. *Applied Sciences*, 13(10). doi:10.3390/app13106039.
- Van den Beemt, A., MacLeod, M., Van der Veen, J., Van de Ven, A., van Baalen, S., Klaassen, R., & Boon, M. (2020). Interdisciplinary engineering education: A review of vision, teaching, and support. *Journal of Engineering Education*, 109(3), 508-555. doi: <https://doi.org/10.1002/jee.20347>.
- Vyawahare, S., & Chakradeo, K. (2020, 18-20 Feb. 2020). *Chatbot Assistant for English as a Second Language Learners*. Paper presented at the 2020 International Conference on Convergence to Digital World - Quo Vadis (ICCDW).
- Zhai, X. (2022). ChatGPT user experience: Implications for education. *Available at SSRN 4312418*.
- Zhuo, T. Y., Huang, Y., Chen, C., & Xing, Z. (2023). Exploring ai ethics of chatgpt: A diagnostic analysis. *arXiv preprint arXiv:2301.12867*.