Education in the Era of Generative Artificial Intelligence (AI): UnderstandingthePotentialBenefitsofChatGPTinPromoting Teaching and Learning

Education in the Era of Generative Artificial Intelligence (AI): Understanding the Potential Benefits of ChatGPT in Promoting Teaching and Learning

D. Baidoo-Anu and **L. Owusu Ansah**

Abstract—Since its maiden release into the public domain, ChatGPT garnered more than one million subscribers within a week. The generative AI tool ChatGPT took the world by surprise with its sophisticated capacity to carry out remarkably complex tasks. The extraordinary abilities of ChatGPT to perform complex tasks within the field of education have caused mixed feelings among educators, as this advancement in AI seems to revolutionize existing educational praxis. This is an exploratory study that synthesizes recent extant literature to offer some potential benefits and drawbacks of ChatGPT in promoting teaching and learning. Benefits of ChatGPT include but are not limited to the promotion of personalized and interactive learning, generating prompts for formative assessment activities that provide ongoing feedback to inform teaching and learning, etc. The paper also highlights some inherent limitations in ChatGPT such as generating incorrect information and biases in data training, which may augment existing biases, and privacy issues. The study offers recommendations on how ChatGPT could be leveraged to maximize teaching and learning. Policymakers, researchers, educators, and technology experts could work together and start conversations on how these evolving generative AI tools could be used safely and constructively to improve education and support students' learning.

Keywords—ChatGPT, Education, Generative AI, Teaching and Learning

I. Introduction

The 21st century has experienced a rapidly changing landscape in educational practices largely due to advancements in technology such as artificial intelligence (AI) [1]. Recent progress and expansion in machine learning have led to more sophisticated innovative technology digital content generation like generative AI [2]. Generative modeling AI (GAI) is an unsupervised or partially supervised machine learning framework that generates manmade relics via the use of statistics, probabilities, etc. [2], [3].

Through advances in deep learning (DL), generative AI creates artificial relics using existing digital content such as but not limited to video, images/graphics, text, audio, and video by examining training examples and learning their patterns and distribution [4], [5].

Extant literature has identified two major generative AI techniques: Generative Adversarial Network (GAN) and Generative Pre-trained Transformer (GPT) [4]-[6]. Currently, GAN is the most common GAI technique used. GAN uses two neural networks: generator and discriminator networks. The generator network generates synthetic data (e.g., an image of someone's face), while the discriminator network examines the genuineness of the content to determine whether the content is authentic or not. This verification process continues until the discriminator network cannot decipher between the synthetic and real content, recognizing synthetic as real [2], [3]. GAN is predominantly used for voice generation, graphics, and video [2]. On the other hand, GPT models use a large amount of publicly available digital content data (natural language processing [NLP]) to read and produce human-like text in several languages and can exhibit creativity in writing from a paragraph to a full research article convincingly on almost any topic [6], [7]. These models are even able to engage customers in human-like conversation such as customer-service chatbots or fictional characters in video games [7]-[10].

A more sophisticated Generative Pre-trained Transformer (GPT)-3 has recently been developed [6]. Using 175 billion parameters, GPT-3 enhances task-agnostic capabilities and even becomes competitive with prior state-of-the-art fine-tuning approaches [6]. GPT-3 has become the basic NLP engine that runs the recently developed language model ChatGPT, which has attracted attention in various fields, including but not limited to education [11], engineering [12], journalism [13], medical [14], and economic and finance [15]. In the next sections, we provide an explanation of what ChatGPT is and its potential to improve education and students' learning. We also discuss some limitations and how educators can use ChatGPT to support and improve students' learning.

II. Methodology

We employed an exploratory methodology to understand the potential benefits of ChatGPT in education. The purpose of this methodology is to systematically review and explore (a) how interactive ChatGPT is, (b) the benefits of ChatGPT and related generative AI in advancing teaching and learning, (c) the possible drawbacks of using ChatGPT and related generative AI in education, reflections, and implications for practice. The study was guided by these research questions: (a) How interactive is ChatGPT? (b) What are the potential benefits of ChatGPT and related generative AI in advancing teaching and learning? (c) What are the possible drawbacks of using ChatGPT and related generative AI in education? The study focused on publicly available resources on ChatGPT from November 2022-March 2023. Specifically, we focused on articles published in peer-reviewed journals or preprints as well as newsletter articles and social media. We were also interested in articles published in the English language.

III. What is ChatGPT?

To begin, we asked ChatGPT to explain itself. The prompt we started with was "What is ChatGPT?". ChatGPT generated this response:

"ChatGPT is a large language model trained by OpenAI. It is designed to generate human-like text based on a given prompt or context. It can be used for a variety of natural language processing tasks, such as text completion, conversation generation, and language translation."

As a follow-up, we used another prompt: "How does it work?". To know how conversational it is, we intentionally wrote "How does it work?" instead of "How does ChatGPT work?". It returned with the response below:

"ChatGPT is based on a transformer architecture, a type of neural network that has been shown to be very effective for natural language processing tasks. It is trained on a large dataset of text, such as books and articles, and learns to generate text that is similar to the text it was trained on. When given a prompt or context, the model processes the input and generates a response. The response is generated one word at a time, with the model predicting the next word based on the input and the words it has generated so far. The model uses attention mechanisms to focus on the most relevant parts of the input and generate a response that is coherent and appropriate for the given context. After the training, the model can be fine-tuned on a specific task such as question answering or dialogue generation by providing it with task-specific examples and fine-tuning the model on this data. It can also generate text in multiple languages by fine-tuning the model on a multilingual dataset or by providing the model with the language code."

Then the topic of conversation was changed to discuss COVID-19 and impacts on educational deliveries using the prompt "Now discuss how COVID-19 has changed educational pedagogies." Within seconds, it wrote the passage below:

The COVID-19 pandemic has had a significant impact on the way education is delivered, with many schools and universities shifting to online or remote learning in order to comply with social distancing guidelines. This has resulted in a rapid shift to digital and online pedagogy, as educators have had to quickly adapt to this new mode of instruction. One of the major changes that have occurred is the increased use of technology for teaching and learning. This has included the use of online learning platforms, such as Zoom, Google Classroom, and other video conferencing tools, as well as the use of digital materials, such as e-books, videos, and interactive activities. This has allowed for increased flexibility and accessibility in the delivery of education, as students can now access materials and participate in classes from anywhere with internet access. Additionally, there has been a shift towards more self-directed and asynchronous learning, where students are given more autonomy in their learning and are able to complete coursework at their own pace. This approach allows students to work at a time that is convenient for them, and it can be beneficial for students who may have other responsibilities or who may have difficulty attending live classes. However, the shift to online learning has also highlighted the digital divide, where students in low-income or rural areas may not have access to the technology or internet connectivity needed to fully participate in remote learning. And it also brought challenges such as a lack of interaction, lack of motivation, and lack of accountability. Overall, COVID-19 has accelerated the adoption of technology and digital pedagogy in education, but it has also highlighted the need for equity and accessibility in the delivery of education. The education system will have to continue to adapt and evolve to meet the needs of students, teachers, and parents during these challenging times.

The outcome clearly shows that ChatGPT is very interactional and capable of not only holding a realistic human-like conversation on a wide range of topics but also producing convincing creative content. Since its maiden release into the public domain, ChatGPT garnered more than one million subscribers within a week [16], [17]. ChatGPT took the world by surprise with its sophisticated capacity and became the hottest topic on social media and news outlets including *Nature* [18] and *The New York Times* [19], among others. ChatGPT has an unprecedented ability to carry out remarkably complex tasks like writing an article [6], story, poem, an essay [20], ability to provide a summary or expansion of a text, adjusting texts to reflect a different perspective, and even write and debug original computer code [11], [21]. The extraordinary abilities of ChatGPT to perform complex tasks within the field of education have caused mixed feelings among educators, as this advancement in AI seems to revolutionize existing educational practices. It has become a contentious topic among educators, while some perceive ChatGPT and related generative AI as the future of teaching and learning, as well as educational research. Others are skeptical and view it as a threat and a potential end to most educational activities, which makes teachers and students lazy with no or

little analytical abilities. So, the question that begs for an answer is whether ChatGPT and related generative AI are the future for teaching and learning or a threat to the education field? We co-authored with ChatGPT to unpack some benefits of ChatGPT and related generative AI in advancing teaching and learning. We also co-authored to discuss the possible drawback of using ChatGPT and related generative AI in education. Implication for practice was discussed.

IV. Benefits of ChatGPT and Related Generative AI in Advancing Teaching and Learning

We queried ChatGPT to generate the benefit of ChatGPT and related generative AI in advancing teaching and learning. The initial prompt was "What are the benefits of ChatGPT and related generative AI in advancing teaching and learning". ChatGPT generated a very brief response which was not detailed. Then when we altered the prompt, ChatGPT also altered the response by providing a detailed explanation. The altered prompt was "I want you to discuss with possible reference the benefits of ChatGPT and related generative AI in advancing teaching and learning". The following detailed responses were generated:

Personalized Tutoring: ChatGPT can be used to provide personalized tutoring and feedback to students based on their individual learning needs and progress. A study by Chen and colleagues [22] demonstrated that a conversational agent based on a generative model (ChatGPT) could provide personalized math tutoring to students, resulting in improved learning outcomes. The study showed that the conversational agent was able to provide explanations that were tailored to students' misconceptions and was able to adapt to their level of understanding.

Automated Essay Grading: ChatGPT can be trained to grade student essays, providing teachers with more time to focus on other aspects of teaching. A study by Kim and colleagues [23] showed that a generative model (ChatGPT) trained on a dataset of human-graded essays could accurately grade essays written by high school students, with a correlation of 0.86 with human grades. The study showed that the model was able to identify key features of well-written essays and was able to provide feedback that was similar to that provided by human graders.

Language Translation: ChatGPT can be used to translate educational materials into different languages, making them more accessible to a wider audience. A study by Johnson and colleagues [24] demonstrated that a generative model (ChatGPT) trained on a dataset of bilingual sentence pairs could accurately translate between languages, achieving state-of-the-art results on several translation benchmarks. The study showed that the model was able to understand the meaning of sentences in one language and to generate accurate translations in another language.

Interactive Learning: ChatGPT can be used to create interactive learning experiences where students can interact with a virtual tutor in a conversational manner. A study by Peng and colleagues [25] demonstrated that a generative model-based conversational agent could provide effective support for students learning English as a second language, resulting in improved language proficiency. The study showed that the agent was able to understand students' questions and to provide appropriate and relevant responses.

Adaptive Learning: ChatGPT can be used to create adaptive learning systems that adjust their teaching methods based on a student's progress and performance. A study by Chiang and colleagues [26] showed that an adaptive learning system based on a generative model (ChatGPT) could provide more effective support for students learning programming, resulting in improved performance on programming assessments. The study showed that the model was able to understand students' knowledge and to adjust the difficulty of the problems it generated accordingly.

Overall, ChatGPT has the potential to be a powerful tool for enhancing teaching and learning by providing personalized tutoring, automated essay grading, language translation, interactive learning, and adaptive learning.

V. Possible Drawbacks of Using ChatGPT and Related Generative AI in Education

To have an overview of the possible drawbacks of incorporating ChatGPT and related generative AI in education, ChatGPT was asked to discuss with references the possible drawbacks of using ChatGPT and related generative AI in education. Below is the outcome of my query.

While there are many potential benefits of using ChatGPT and other generative AI models in education, there are also some drawbacks to consider. These drawbacks are supported by research studies:

Lack of Human Interaction: ChatGPT and other generative models are not capable of providing the same level of human interaction as a real teacher or tutor. This lack of human interaction can be a disadvantage for students who may benefit more from a personal connection with a teacher. A study by D'Mello and colleagues [27] found that students who interacted with a virtual tutor that mimicked human-like affective behavior had better learning outcomes than those who interacted with a virtual tutor that lacked this behavior.

Limited Understanding: Generative models are based on statistical patterns in the data they are trained on, and they do not have a true understanding of the concepts they are helping students learn. This can be a disadvantage when it comes to providing explanations or feedback that are tailored to a student's individual needs and misconceptions. A study by Wang and colleagues [28] showed that a generative model-based tutoring system lacked the ability to provide explanations that were tailored to students' misconceptions.

Bias in Training Data: Generative models are only as good as the data they are trained on, and if the training data contains biases, the model will also be biased. For example, if a model is trained on a dataset of essays that are primarily written by students from a certain demographic, it may not be able to accurately grade essays written by students from other demographics. A study by Bolukbasi and colleagues [29] showed that a generative model trained on a large corpus of text from the internet exhibited gender bias in its language generation.

Lack of Creativity: Generative models can only generate responses based on the patterns in the data they have seen during training, which can limit the creativity and originality of the responses. A study by Ziegler and colleagues [30] found that a generative model-based music composition system had a limited ability to generate original and diverse melodies.

Dependency on Data: Generative models are trained on a large amount of data, and the quality of the model is highly dependent on the quality and quantity of the data. If the data is not sufficient or not relevant, the model will not be able to perform as well. A study by Kocaguneli and colleagues [31] showed that a generative model-based question answering system performed poorly when the training data was not relevant to the task at hand.

Lack of Contextual Understanding: Generative models lack the ability to understand context and situation, which can lead to inappropriate or irrelevant responses. A study by Gao and colleagues [32] showed that a generative model-based dialogue system had a limited ability to understand and generate contextually appropriate responses in a conversation.

Limited ability to personalize instruction: ChatGPT and other generative AI models can provide general information and assistance, but they may not be able to personalize instruction to meet the individual needs of a particular student [33].

Privacy: There are also concerns about privacy and data security when using ChatGPT and other generative AI models in education [33].

It is important to keep in mind that ChatGPT and other generative AI models are powerful tools, but they are not a replacement for human teachers and tutors. It is important to use these tools responsibly and in conjunction with human instruction and support [33].

Overall, while generative AI models such as ChatGPT can be powerful tools for enhancing teaching and learning, it is important to be aware of their limitations and to use them in conjunction with other teaching methods that emphasize human interaction and understanding.

VI. Reflections and Implications for Practice

Undoubtedly, ChatGPT and other generative AI is already pushing educational boundaries and initiating a significant paradigm shift in existing educational praxis. Since its introduction to the public in 2022, educators have written extensively about potential implications for teachers, students, and policy. Some educators have already started testing the efficiency of ChatGPT by integrating it in their educational activities (e.g., research, teaching, assessment) and found that through automation of certain tasks and processes, ChatGPT is able to save time for other important activities like spending more time with students [15], [26]. For example, Terwiesch who is a Professor at the Wharton School of the University of Pennsylvania indicated that it usually takes 20 hours of work to create an exam and another 10 hours for TAs to test the exam and write solutions to it. However, ChatGPT was able to create the exams within 10 hours and reduced TAs time to 5 hours. This shows 100% productivity increase in the "exam writing operation" [26]. Similarly, Zhai [34] stated that it took him 2-3 hours to conduct a study on ChatGPT. He said "…the entire process, including generating and trying queries, adding subtitles, and reviewing and organizing the content, took 2-3 hours" [34]. Researchers were able to ask OpenAI's GPT-3 to write an academic paper about itself and how it works [35]. The paper was submitted to an academic journal.

Herft [36] has also identified several ways teachers could use ChatGPT to support and improve their pedagogical and assessment practices. For example, teachers can leverage the capabilities of ChatGPT to create prompts for open-ended questions that align with the learning goals and success criteria of the unit of instruction. Additionally, ChatGPT can be used to also generate quality rubrics that clearly and concisely explain exactly what students need to accomplish to be successful in the various required levels of proficiency. Again, teachers can use ChatGPT to create "prompts for formative assessment activities that provide ongoing feedback to inform teaching and learning" [36]. Thus, generative AI-powered assessment systems may support the integration of continuous feedback into learning processes by utilizing distinctive and atypical artifacts. Students can also use ChatGPT and other chatbots to support their learning. For instance, students could leverage the capacity of these advanced generative AI to provide systematic explanations of certain complex concepts. ChatGPT can serve as a virtual tutor, which can answer students' questions and provide

explanations to a wide range of subjects. This can be particularly useful for students who are struggling with a particular topic or who need extra help outside of the classroom. Also, studies have found that non-native speakers of national languages and students with learning and language disabilities (i.e., struggles to write well) will benefit most from these natural language models. There are a wide range of student-centered learning approaches that can be constructed to be played in groups. The ChatGPT and related generative AI have the capacity to create distinct scenarios for

students to collaborate to solve problems and achieve goals. In this way, students can learn from each other, which promote a sense of community among learners. Arguably, ChatGPT has a great potential to support and advance the work of educators, students and researchers.

Despite the myriad of potential educational benefits, in its current state ChatGPT has been found to have several serious inherent limitations, such as generating wrong answers and making-up articles that do not exist. For example, an author asked ChatGPT to generate books and articles in a paper he is working on, ChatGPT included a make-up article which does not exist and even provided full bibliographic details of the article with a non-functional URL [12]. These limitations and other glitches have been reported in other studies. Similarly, when we asked ChatGPT to discuss with references the possible drawback of using ChatGPT and related generative AI in education, it fabricated a reference "Ribeiro and Vala, 2020" to support its discussion. When we asked for ChatGPT to reference the citation it stated "A Survey on Generative Artificial Intelligence" by Ribeiro and Vala, which was published in the Proceedings of the 1st International Conference on Emerging Trends in Intelligent Computing and Informatics (ETICI 2020). Deep search for 'Ribeiro and Vala, 2020' work revealed that there is no conference presentation by Ribeiro and Vala, 2020 on generative artificial AI. Therefore, we have reasons to believe that this was a fabricated article. This confirms a tweet from the CEO of OpenAI, Sam Altman, who described ChatGPT as "incredibly limited, but good enough at some things to create a misleading impression of greatness. It's a mistake to be relying on it for anything important right now. It's a preview of progress; we have lots of work to do on robustness and truthfulness." (Tweet on December 11, 2022). Again, a cursory look at the ChatGPT-generated responses in this study reveals that it has no idea of the world after 2021. Hence it could not add any references or information after 2021. This is because ChatGPT was trained with information only up to 2021 [18]. Given these inherent limitations, educators, researchers, students and other professionals who use ChatGPT and other chatbot should be cautious.

VII. Conclusion and the Way Forward

Despite its inherent limitations, it is a nearly undeniable fact that ChatGPT and other generative AI have come to stay and will continue revolutionizing the current educational system. Many have called for ChatGPT to be banned in schools while others have started developing software to detect AI-generated texts (see, https://writer.com/ai-content-detector/ and https://huggingface.co/roberta-base-openai-detector). Others have also provided tips that teachers can use to prevent students from using ChatGPT in writing their essays and other school assignments. For example, Elsen-Rooney [37] reported that the New York City Education Department (NYC) has blocked ChatGPT on school devices and networks so that students and teachers can no longer access ChatGPT. While these various strategies may work for a while, it may not stand the test of time with even more sophisticated generative AI like GPT-5, which is anticipated to come in the not-too-distant future.

Currently, extant literature has shown that AI-generated text detectors are not effective with current sophisticated natural processing language models [11], [21]. We should not lose sight of the fact that students also have access to these detectors and can alter the text generated to ensure that it becomes undetectable. In lieu of this, it is high time we began to accept the rapidly changing landscape in educational practices and incorporate these changes in our current educational praxis. Moreover, with Microsoft trying to incorporate ChatGPT holistically into its products [38], [39], in no time ChatGPT will be conventional, and it may possibly be too late for educational institutions to rethink their policies and practices to guide and support their students in using ChatGPT safely and constructively. One area that has garnered more attention and become topical is students' assessment. It is too soon to conclude but very soon educators may need to rethink how students are assessed. They may have to change how assessment is currently done to more innovative assessments. Extant literature has demonstrated that teachers have limited capacity and skills to engage in high-quality assessment practices that move learning forward. In lieu of this, educators have consistently called on teachers to

develop capacity to engage students in high-quality assessment practices [40], [41], [42]. Through professional capacity building, teachers could develop the skills needed to harness the power of ChatGPT and other generative AI to engage in high-quality assessment practices that improve students' learning. Given the increase in AI even in workspaces, integrating generative AI tools in the classroom and teaching students how to use it constructively and safely could also prepare them to thrive in an AI-dominated work environment after school. Therefore, educators could harness generative AI models like the ChatGPT to support students' learning. Some questions need urgent answers, for example, how can we leverage ChatGPT to support students' learning? Do we need to train teachers and students on how they can use current generative AI tools to improve teaching and learning? How can we integrate generative AI tools into teacher education programs to prepare teacher candidates or pre-service teachers to effectively use AI tools in their classrooms? Will these generative AI tools close or augment existing digital divide and what is the way forward? Policy makers, researchers, educators and technology experts should work together and start conversations on how these evolving generative AI tools could be used safely and constructively to improve education and support students' learning.

References

[1] Petersen, J. (2021). Innovative assessment practices. Retrieved on 2 August 2022 from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ah UKEwjhzbGO38T5AhW2hIkEHXPNDdoQFnoECAkQAQ&url=https%3A%2F%2Ffreshgrade.com %2Fwp-content%2Fuploads%2F2020%2F07%2FFG-Innovative-Assessment-Whitepaper-1.pdf&usg=AOvVaw1fWCFBStSE4BqDTXT5_Voi.

[2] Hu, L. (2023). Generative AI and Future. Retrieved on January 23 from https://pub.towardsai.net/generative-ai-and-future-c3b1695876f2.

[3] Jovanović, M. (2023). Generative Artificial Intelligence: Trends and Prospects. https://www.computer.org/csdl/magazine/co/2022/10/09903869/1H0G6xvtREk. 0.1109/MC.2022.3192720.

[4] Abukmeil, M., Ferrari, S., Genovese, A., Piuri, V., & Scotti, F. (2021). A survey of unsupervised generative models for exploratory data analysis and representation learning. ACM computing surveys (CSUR), 54(5), 1-40. https://doi.org/10.1145/3450963.

[5] Gui, J., Sun, Z., Wen, Y., Tao, D., & Ye, J. (2021). A review on generative adversarial networks: Algorithms, theory, and applications. IEEE Transactions on Knowledge and Data Engineering. doi: 10.1109/TKDE.2021.3130191.

[6] Brown, T., Mann, B., Ryder, N., Subbiah, M., Kaplan, J. D., Dhariwal, P., et al. (2020). Language models are few-shot learners. Advances in Neural Information Processing Systems, 33: 1877-1901.

[7] Aydın, Ö., Karaarslan, E. (2022). OpenAI ChatGPT Generated Literature Review: Digital Twin in Healthcare. In Ö. Aydın (Ed.), Emerging Computer Technologies 2 (pp. 22-31). İzmir Akademi Dernegi.

[8] Aydın, Ö., & Karaarslan, E. (2023). Is ChatGPT leading generative AI? What is beyond expectations? Academic Platform Journal of Engineering and Smart Systems.

[9] Korngiebel, D. M., Fullerton, S. M., & Burke, W. (2021). Health disparities, data collection, and the promise of artificial intelligence. JAMA, 324(2), 171-172.

[10] Pavlik, J. V. (2023). Collaborating With ChatGPT: Considering the Implications of Generative Artificial Intelligence for Journalism and Media Education. Journalism & Mass Communication Educator, 0(0). https://doi.org/10.1177/107769582

   1.

[11] Williams, C. (2023). Hype, or the future of learning and teaching? 3 Limits to AI's ability to write student essays. . London School of Economics internet blog. https://kar.kent.ac.uk/99505/.

[12] Qadir, Junaid (2022): Engineering Education in the Era of ChatGPT: Promise and Pitfalls of Generative AI for Education. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.21789434.v1.

[13] Metz, C. (2022, Dec.11). The new chatbots could change the world. Can you trust them? The New York Times. https://www.nytimes.com/2022/12/10/technology/ai-chat-bot-chatgpt.html.

[14] O'Connor, S., & ChatGPT. (2023). Open artificial intelligence platforms in nursing education: Tools for academic progress or abuse? Nurse Education in Practice, 66, 103-537. https://doi.org/10.1016/j.nepr.2022.103537.

[15] Alshater, M. (2022). Exploring the role of artificial intelligence in enhancing academic performance: A case study of ChatGPT (December 26, 2022). Available at SSRN: https://ssrn.com/abstract=4312358 or http://dx.doi.org/10.2139/ssrn.4312358.

[16] Altman, S. (2022, Dec. 4). Twitter. https://twitter.com/sama/status/1599668808285028353?s=20&t=j5ymf1tUeTpeQuJKlWAKaQ.

[17] Mollman, S. (2022, December 9). ChatGPT has gained 1 million followers in a single week. Here's why the A.I. chatbot is primed to disrupt search as we know it. Yahoo Finance. https://finance.yahoo.com/news/chatgpt-gained-1-million-followers-224523258.html?guccounter=1&guce_referrer=aHR0cHM6Ly9kdWNrZHVja2dvLmNvbS8&guceref errer_sig=AQAAAFoaVt0Jgmrz33m4F8LQ93tU37YKNp45BNiRU295yW5YSO9Pki.

[18] OpenAI. (2022). ChatGPT: Optimizing language models for dialogue. OpenAI. Published November 30, 2022. Accessed January 17, 2022. https://openai.com/blog/chatgpt/.

[19] Stokel-Walker, C. (2022, Dec. 2). What is ChatGPT and why does it matter? Here's what you need to know. Nature. https://www.nature.com/articles/d41586-022-03789-0.

[20] Lucy, L., & Bamman, D. (2021, June). Gender and representation bias in GPT-3 generated stories. In Proceedings of the Third Workshop on Narrative Understanding (pp. 48-55). http://dx.doi.org/10.18653/v1/2021.nuse-1.5.

[21] Tate, T. P., Doroudi, S., Ritchie, D., Xu, Y., & Uci, m. w. (2023, January 10). Educational Research and AI-Generated Writing: Confronting the Coming Tsunami. https://doi.org/10.35542/osf.io/4mec3.

[22] Chen, Y., Chen, Y., & Heffernan, N. (2020). Personalized math tutoring with a conversational agent. arXiv preprint arXiv:2012.12121.

[23] Kim, S., Park, J., & Lee, H. (2019). Automated essay scoring using a deep learning model. Journal of Educational Technology Development and Exchange, 2(1), 1-17.

[24] Johnson, M., Schuster, M., Le, Q., Krikun, M., Wu, Y., Chen, Z., ... & Chen, Y. (2016). Google's neural machine translation system: Bridging the gap between human and machine translation. arXiv preprint arXiv:1609.08144.

[25] Peng, P., Fuchs, L. S., & Fuchs, D. (2022). A review of the research on generative learning and assessment. Review of Educational Research, 89(3), 441-468.

[26] Terwiesch, C. (2023). Would Chat GPT3 get a Wharton MBA? A prediction based on its performance in the operations management course. Mack Institute for Innovation Management at the Wharton School: University of Pennsylvania.

[27] D'Mello, S., Craig, S., Witherspoon, A., & Graesser, A. (2014). Affective and learning-related dynamics during interactions with an intelligent tutoring system. International Journal of Human-Computer Studies, 72(6), 415-435.

[28] Wang, W., Chen, Y., & Heffernan, N. (2020). A generative model-based tutoring system for math word problems. arXiv preprint arXiv:2010.04856.

[29] Bolukbasi, T., Chang, K. W., Zou, J. Y., Saligrama, V., & Kalai, A. T. (2016). Man is to computer programmer as woman is to homemaker? Debiasing word embeddings. In *Advances in Neural Information Processing Systems* (pp. 4349-4357).

[30] Ziegler, N., Pinter, F., & Fingerhuth, J. (2019). Music composition with deep generative models. In Proceedings of the 2nd Workshop on Machine Learning for Creativity (pp. 1-8).

[31] Kocaguneli, E., Menzies, T., & Keung, J. (2019). A large-scale empirical comparison of object-oriented design metrics and static code analysis alarms. *IEEE Transactions on Software Engineering*, 45(4), 344-362.

[32] Gao, J., Galley, M., & Li, L. (2019). Neural approaches to conversational AI: Question answering, task-oriented dialog, and social chatbots. *Foundations and Trends in Information Retrieval*, 13(2-3), 127-298.

[33] Ribeiro, B., & Vala, F. (2020). A Survey on Generative Artificial Intelligence. In Proceedings of the 1st International Conference on Emerging Trends in Intelligent Computing and Informatics (ETICI 2020).

[34] Zhai, X., (2022). ChatGPT User experience: Implications for education. (December 27, 2022). Available at SSRN: https://ssrn.com/abstract=4312418 or http://dx.doi.org/10.2139/ssrn.4312418.

[35] Thunstrom, A. O. (2022, June 30). We asked GPT-3 to write an academic paper about itself- then we tried to get it published. Scientific American. https://www.scientificamerican.com/article/we-asked-gpt-3-to-write-an-academic-paper-about-itself-mdash-then-we-tried-to-get-it-published/.

[36] Herft, A. (2023). A Teacher's Prompt Guide to ChatGPT aligned with 'What Works Best' Guide. Retrieved on January 23 2023 from https://drive.google.com/file/d/15qAxnUzOwAPwHzoaKBJd8FAgiOZYcIxq/view.

[37] Elsen-Rooney, M. (2023). NYC education department blocks ChatGPT on school devices, networks. Retrieved on January 24 2023 from https://ny.chalkbeat.org/2023/1/3/23537987/nyc-schools-ban-chatgpt-writing-artificial-intelligence.

[38] 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). https://doi.org/10.37074/jalt.2023.6.1.9.

[39] Warren, T. (2023, January 9). Microsoft is looking at OpenAI's GPT for Word, Outlook, and PowerPoint. The Verge, https://www.theverge.com/2023/1/9/23546144/microsoft-openai-word-powerpoint-outlook-gpt-integration-rumor.

[40] Earl, L. M. (2012). Assessment as learning: Using classroom assessment to maximize student learning. Corwin Press.

[41] Wiliam, D. (2011). What is assessment for learning?. Studies in Educational Evaluation, 37(1), 3-14. https://doi.org/10.1016/j.stueduc.2011.03.001.

[42] Willis, J., Adie, L., & Klenowski, V. (2013). Conceptualising teachers' assessment literacies in an era of curriculum and assessment reform. The Australian Educational Researcher, 40, 241-256. https://doi.org/10.1007/s13384-013-0089-9.