The Impact of Generative Artificial Intelligence on Education: A Comparative Study

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Abstract: Generative Artificial Intelligence (GAI), also known as creative AI, is a technology capable of independently producing original and creative content, such as text, images, videos, music, or code. It uses machine learning algorithms to analyze and learn from a vast amount of data to generate similar or even innovative content. This type of AI is used in several fields, such as health for the production of new drugs, design to generate adaptive designs, video games to create immersive environments, and artificial intelligence to generate training data for new networks. Seizing the opportunities offered by AI innovations in education is crucial. We cannot afford to let time pass without doing anything and without benefiting from this technique. It is time to enhance traditional learning methods and adopt more innovative approaches that take advantage of the potential of AI, like content and exam generation, and also improve students' learning experience by exploiting their closeness to the technology. This paper aims to answer the question of when and how to use artificial intelligence responsibly, considering it as a technology and limiting its excessive use. Additionally, we present the impact of GAI through a comparative study of student performance in three exam types: a classical MCQ exam written by the teacher, an adaptive MCQ exam generated by GAI from a topic, and a third MCQ exam generated by GAI based on the content of the provided documents. This study is conducted on students undergoing a software testing training program. By evaluating their performance in the AI-generated adaptive MCQ exams and the traditional MCQ exam, we can gain insights into the potential of this technology to enhance educational practices and provide personalized learning experiences. This research will contribute to the ongoing discussion on responsible and effective utilization of GAI in education, paving the way for future advancements in the field.

Keywords: IA, Education, Learning experiences, Generative AI, educational content, Generative artificial intelligence, Adaptive exam, MCQ

1. Introduction

Artificial Intelligence (AI) is a branch of computer science dedicated to developing intelligent machines capable of performing tasks that typically require human intelligence (Lu, 2019). One of its subfields is Generative AI, which utilizes machine learning models to create new and original content, such as images, text, music, and even data for training other machine learning models (Elmourabit et al., 2024). This technology has diverse applications across various fields, including art generation, content creation, and even educational settings, In the realm of education, the use of AI has been increasingly prominent.

AI technologies, including generative AI (GAI), are being integrated into educational systems to enhance learning experiences. GAI in education can be utilized to provide instant access to vast amounts of information, aid diverse learners with different abilities, accelerate exploration and creativity, and improve student outcomes (Walkington et al., 2020). Both students and faculty can benefit from GAI by efficiently completing coursework, generating ideas for brainstorming, improving writing skills, and creating course materials like lesson plans and quiz questions.

The integration of GAI in education has the potential to revolutionize the learning experience by offering personalized learning, efficient content creation, enhanced student engagement, and real-time adaptive assessment and feedback. Personalized learning can be achieved through customized learning materials tailored to individual students' needs, preferences, and learning styles. GAI can assist in creating new teaching materials, such as questions for quizzes and exercises or explanations and summaries of concepts, making content creation more efficient. Additionally, it can create simulations and virtual environments, offering more engagement and interactive courses, and improving students' learning experience. Real-time adaptive assessment and feedback can be facilitated by this technology, allowing students to be challenged at an appropriate level and fostering continuous growth and improvement. As the field of AI continues to evolve (Bert et al, 2023), its applications in education are poised to reshape the future of learning by fostering innovation, efficiency, and improved educational outcomes.

In this work, we present the impact of GAI on the educational system by introducing, in the first section, the benefits of this AI technology in education. These benefits include personalized learning, efficient content creation, student engagement, and real-time assessment and feedback. In this subsection, we present a comparative study in the second section about the impact of adaptive exams generated by GAI and the classical exam on student performance. The third section is dedicated to the ethical implications of GAI as a technology, and nothing else. The paper concludes in the fourth and final section.

2. GAI Benefits in Education

Neural networks, which are intended to mimic the human brain by learning from enormous amounts of data, are the basis for generative artificial intelligence. These algorithms look for relationships, analyze patterns, and produce new outputs that mimic the properties of the training data. With this novel method, generative AI may create customized and one-of-a-kind learning experiences. The integration of GAI into education is transforming the way we teach and learn. Thanks to technological advances, AI can potentially improve educational experiences in different ways:

2.1 Personalized Learning and Content Creation

Personalized learning is a pedagogical approach that adapts teaching and learning experiences to meet the specific needs, interests, and abilities of each learner (Walkington et al, 2020). It recognizes that every student possesses unique learning preferences, strengths, and weaknesses (Bray et al, 2014), and aims to provide a more tailored and personalized learning experience. The goal of personalized learning is to foster increased engagement, relevance, and effectiveness, ultimately maximizing each student's potential for academic success and personal growth. Effective content generation in education requires an understanding of the subject matter (Shemshack et al, 2020), pedagogical best practices, and diverse student learning styles. Generative AI (GAI) models can analyze student data, including their learning speed, strengths, weaknesses, areas of difficulty, and progress over time, to dynamically generate personalized learning materials and activities tailored to individual needs (Ikhlass et al, 2016). This level of personalization has been shown to foster increased engagement, relevance, and effectiveness, contributing to more successful learning outcomes. Furthermore, through process mining techniques (Chanaa et al, 2018), GAI can create personalized learning pathways that adapt to the specific learning pace and challenges of each individual, minimizing dropout rates and ensuring that students receive the targeted support and content they require. Additionally, these models can provide personalized recommendations, such as suggesting relevant, generated content or offering targeted explanations, to further enhance the learning experience (Khazanchi et al, 2024). As the capabilities of GAI continue to evolve, the integration of these technologies into content creation for education holds immense promise for revolutionizing the way we approach personalized learning (Ali et al, 2023), catering to the diverse needs of all students, and helping them reach their full academic and personal potential. (Pataranutaporn et al, 2021) used Generative Adversarial Networks (GANs) to create AI-generated characters that can bring history, science, and art to life, serving as virtual instructors and enhancing learners' motivation, attention, and engagement. These characters can be used in various educational settings, from classrooms to museums, to deliver compelling learning materials and optimize the student-teacher relationship. In another context, (Song et al, 2023) propose a framework utilizing LLMs to enhance text-to-SQL translation, enabling the system to comprehend natural language queries. This work demonstrates effectiveness in constructing a practical AI system. A recent study conducted by Nguyen et al in 2024 has shed light on the patterns of collaboration between humans and AI in the context of AI-assisted academic writing (Nguyen et al, 2024). This research provides insights into how large-scale language model-based AI tools are being integrated into the writing process. It highlights how these technologies complement human skills to enhance productivity, creativity, and efficiency in academic writing tasks.

2.2 Student Engagement

Student engagement is a complex concept that encompasses various dimensions (Groccia, 2018), including intellectual, emotional, behavioral, physical, and social factors that influence learning (Essie, S. 2021). Intellectual engagement refers to the use of strategies that stimulate curiosity and interest in learning, such as providing students with choices or introducing a unit of study with a problem to solve. Emotional engagement involves promoting positive emotions and minimizing negative behaviors to facilitate learning. Behavioral engagement includes establishing routines and using consistent cues to foster behaviors conducive to learning (McFadden et al, 2002). Physical engagement involves using physical activities or routines to stimulate learning and interest (Biddle et al, 2011). Social engagement refers to using strategies that stimulate engagement through social interactions (Ouhaddou et al, 2023), such as pairing or grouping students to work collaboratively on

projects. While the concept of student engagement is straightforward, it can take complex forms in practice, and educators may hold different views on student engagement, defining or interpreting it differently from place to place. Generative AI offers various benefits for student engagement in higher education. Utilizing AI tools like ChatGPT and DALL.E2 can promote experiential learning (Kasneci et al., 2023), student engagement, and collaboration (Bert et al, 2023). This approach involves authentic assessments that require students to apply knowledge and skills in real-world tasks, fostering higher engagement and performance. Additionally, encouraging students to use GAI to generate creative ideas and solutions to complex problems can facilitate both divergent and convergent thinking processes, aiding students in developing, testing, and evaluating innovative solutions. Furthermore, employing AI as a copyediting tool can enhance students' writing and presentation skills. By comparing their work with AI-generated outputs, students can improve their language, style, and tone, which is particularly beneficial for non-native English speakers seeking clarity and expression in their academic work. These applications of generative AI not only enhance student engagement but also foster creativity (El Maazouzi et al, 2023), critical thinking, and problem-solving skills essential for preparing students for the challenges of the future. Al Yakin et al. (Al Yakin et al, 2023) explored the use of the AI chatbot, ChatGPT, to enhance online student engagement in sociology and politics education. The research was conducted with 23 fourth-semester undergraduate students and found that ChatGPT generated enthusiasm and high levels of student engagement. Specifically, ChatGPT facilitated activities such as idea exchange, discussions, analysis, and motivation among the students. The effectiveness of ChatGPT in enhancing student engagement was measured through a questionnaire filled out by the students using a Likert Scale, which included 16 positive statements about ChatGPT. The researchers highlight the potential of AI technology in education, as ChatGPT provides immediate, concise, and relevant responses to students' questions and concerns, allowing for active discussion, feedback, and interaction. However, the study emphasizes that the integration of ChatGPT in education requires well-defined and frequent, quality interaction with instructors to maximize its potential for enhancing student engagement. Recent research published in Nature (Pataranutaporn et al, 2021) has highlighted the potential of Generative Adversarial Network (GAN) architectures to enable personalized learning experiences for students. The study demonstrates how students can significantly enhance their engagement with course material and interactions with their peers through direct virtual interactions with relevant historical figures related to the study context. For instance, when exploring physics, students can now have the opportunity to interact virtually with iconic figures like Albert Einstein. Similarly, during an art class, learners can engage with the likes of the enigmatic Mona Lisa. This innovative approach immerses students in the subject matter by bringing these historical luminaries to life, fostering a deeper connection with the content, and stimulating curiosity and enthusiasm for learning. The researchers highlight that this GAN-powered approach to education represents a significant advancement, as it allows learners to engage with the course material in a more immersive and personalized manner. By facilitating direct interactions with influential historical figures, students can develop a stronger understanding and appreciation for the subject, ultimately leading to enhanced engagement and learning outcomes. Duolingo has unveiled a collaboration with OpenAI on the Duolingo Max project (Duolingo, 2023), which aims to integrate generative AI into its repertoire. This will introduce two new features for learners: "Explain My Answer" and "Role Play." The former provides a chatbot that offers students personalized and timely feedback on incorrect answers. The latter introduces an innovative feature allowing students to engage in unscripted discussions in any language with various characters within the Duolingo app. These new generative AI features aim to enhance the learning experience of Duolingo users by providing personalized support and opportunities for authentic conversational practice.

2.3 Real-Time Assessment and Feedback

Assessment is the systematic way of evaluating how much a student understands from what has been taught and how well they can do when they are given the test. Assessment encompasses collecting, gathering, and analyzing information about what students know (Jackel et al, 2017), understand, and can do. This information is used to identify their educational needs and to monitor their progress. The students can be evaluated academically through formative assessments, projects, tests, assignments, essays, and presentations, while non-academically evaluation can be done through observation. Feedback, derived from the English work feed + back, is the information provided to students about their performance or progress. Effective feedback should be timely, specific, and focused on helping students improve. It can come from teachers, peers, or self-assessment, and it helps students understand their strengths, weaknesses, and areas for growth. Feedback is a crucial part of the learning process, as it guides students in developing their skills and knowledge. Together, assessment and feedback play a critical role in supporting student learning and development in educational settings. GAI can assist in evaluating students' work by examining written assignments, presentations, and spoken responses, providing comprehensive feedback that covers both the textual and auditory elements of the content. Thus,

generative AI is transforming the educational field, making it more interactive and adaptable to the needs of today's learners. Researchers at the University of Georgia (Barrett et al, 2019) have used AI-based virtual teaching assistants to help professors with their administrative tasks, answer student questions, and provide personalized feedback on assignments. The research article (Tenakwah et al, 2023) explores the implications of using generative AI, particularly ChatGPT, in higher education assessments. The authors highlight the potential for academic dishonesty if students use ChatGPT to generate responses and pass them off as their work on exams and assignments. This raises concerns about the intellectual and practical preparedness of future graduates, prompting discussions on the future of higher education assessments. The article suggests that educators must adapt their assessment methodologies to account for these risks and prevent academic misconduct. Educators are encouraged to be aware of the tools available to students, including ChatGPT, and to differentiate their assessment and learning processes accordingly. Additionally, the authors recommend that students who utilize AI systems should be encouraged to acknowledge their contribution to assignments, as a means of improving academic openness and integrity. Overall, the research emphasizes the need for higher education institutions to navigate the complexities introduced by the integration of generative AI technologies into assessment practices. Coursera (Minudri, 2023) used the power of GAI to analyze student submissions and provide automated feedback, including error corrections, tips, and explanations. By receiving immediate feedback, students can identify areas for improvement, rectify errors, and deepen their understanding of the subject. In addition, Coursera Coach is also trying to make the platform more accessible by including machine translation models to allow students to take courses in their language. The blog from (Eklavvya, 2024) discusses the use of AI in generating question papers, offering efficient and automated solutions for this task. It highlights the challenges of manual question paper generation and the benefits of AI tools in streamlining the process. The platform provides features like generating questions based on subject, topic, difficulty level, or specific paragraphs. Additionally, it allows for the import of questions by subject experts, ensuring secure and reliable question paper generation. The system supports the customization of question papers by defining parameters like question type, subject, topic, difficulty level, and marks per question. It also explains how the randomization of questions works to create unique sets of question papers for students automatically.

In the previous section, we presented the benefits of GAI on education, including personalized learning, efficient content creation, improved student engagement, and real-time assessment and feedback, along with some related works in this area. In the next section, we present our comparative study about the impact of GAI through a comparative study between student performance in an adaptive Multiple-Choice Questions (MCQ) exam generated by AI from the given courses and a classical MCQ exam written by the teacher.

3. Study Results and Discussions

In this section, we present the results of our comparative study between student performance on three different types of assessments:

- Exam 1: The traditional, teacher-written classical MCQ exam.
- Exam 2: The AI-generated adaptive MCQ exam without any human intervention or given source material (e.g. course documents, MCQs).
- Exam 3: The AI-generated adaptive MCQ exam was created from the given course materials and sample exercises. This system was developed using GPT language models.

The study was performed with a cohort of 25 students with a computer science background.

For Traditional Exam 1, it takes almost 1 hour to gather the questions and select the correct answer, as well as the incorrect answers which are often similar to the correct one. It also requires materials to grade the students' answer sheets, which takes an additional 30 minutes. In total, the process of preparing and grading the multiple-choice exam takes almost 1 and a half hours. For Exam 2, which is generated by AI, it takes almost 5 minutes to generate the questions from a given topic, such as "Software Testing / QA". For Exam 3, which is also generated by AI, the process takes almost 20 minutes. This involves using provided resources such as short course material and examples from previous exams. It also requires some intervention from the professor.

Table 1: Duration of each exam preparation

Exam Type	Duration (Minute)
Exam 1	90
Exam 2	5

Exam Type	Duration (Minute)
Exam 3	20

This table clearly shows that the AI-generated exams (Exam 2 and Exam 3) take much less time to prepare compared to the traditional exam (Exam 1). This shows that using GAI to generate exams can help reduce the time and effort needed, which can be a significant advantage. The AI-based approaches allow for faster exam preparation and grading, which can be valuable for both instructors and students.

According to the grading scale defined, where scores between 0 and 10 are assigned an F, 10 to 12 a D, 12 to 14 a C, 14 to 16 a B, 16 to 18 an A, and 18 to 20 an A+, the student results on the three exam types are distributed as follows:

Table 2: Student Grades on Each Exam Type.

Exam Type	A+	A	B	C	D	F
Exam 1	1	5	7	5	5	2
Exam 2	-	-	5	6	12	2
Exam 3	5	8	10	2	-	-

For Exam 1, 7 students received a B grade, 5 received a D, 5 received a C, 5 received an A, 2 received an F, and 1 received an A+.

On the AI-generated Exam 2 from a topic, 12 students received a D grade, 6 received a C, 5 received a B, and 2 received an F.

For Exam 3 from resources, 10 students received a B grade, 8 received an A, and 5 received an A+, with 2 receiving a C.

These detailed grade distributions show that while the traditional Exam 1 had a wider spread of grades, the AI-generated exams, particularly Exam 2, saw more students clustered in the lower letter grades. In contrast, Exam 3 generated the highest number of A and A+ grades among the three exam types. Based on this result we can see that the AI-generated exams, when properly implemented with teacher intervention, can indeed promote better student performance compared to the traditional exam.

- For Exam 3, which likely benefited from teacher guidance and curation of the resources used, the grade distribution skews much higher, with the majority of students earning A and A+ grades.
- In contrast, Exam 2, which was created without explicit teacher oversight, resulted in a higher number of lower D grades compared to the other exams.

This suggests that when the AI generation process is coupled with thoughtful teacher intervention - such as selecting appropriate input materials, reviewing the exam content, and providing feedback, the GAI can be leveraged to enhance student learning and better assessment outcomes.

The teacher's role in guiding and refining the GAI exams appears to be a critical factor in unlocking the full potential of this technology to improve educational assessment. With the right balance of human oversight and AI capabilities, the results indicate the possibility of promoting better student performance and learning.

Table 3: Class Average Scores for Each Exam (out of 20)

Exam	Average
Exam 1	13.56
Exam 2	11.80
Exam 3	15.72

As we can see from Table 3, the highest-class average is for Exam 3 at 15.72 out of 20, which was the AI-generated exam from resources. The traditional Exam 1 had a class average of 13.56 out of 20. The lowest class average was for Exam 2, the AI-generated exam from a topic, at 11.80 out of 20. These results further reinforce the observation that when the AI generation process is guided and overseen by the instructor, as was likely the case for Exam 3, the student performance and learning outcomes can be enhanced compared to a traditional exam format. Conversely, the AI-generated exam without sufficient teacher intervention, as with Exam 2, did

not achieve the same level of class performance. The class average scores provide a clear quantitative measure of how the different exam formats impacted overall student learning and mastery of the material.

Exam 2 was generated by the GAI system only according to the given subject, without any direct supervision or curation by the teacher. As a result, the questions of this exam may have been limited in scope, focusing narrowly on certain aspects of the subject. In addition, AI has generated some questions and answers that are even completely removed from the main topic. Since AI generated the exam questions autonomously, without the benefit of the professor's expertise in sequencing, pace, and aligning content to broader learning objectives, the resulting examination was able to test a narrower and inappropriate range of knowledge than expected. This substantial limitation in the relevance and depth of the content of the exam is reflected in the class average score of 11.80, suggesting that greater involvement of teachers in the design process of AI-generated assessments is crucial to ensure alignment and effectiveness.

4. Ethical Implications of GAI as a Technology

The use of GAI in education offers many benefits but also raises several critical concerns that require careful consideration and proactive measures. A major concern is data privacy and security. The collection and analysis of comprehensive student data raises questions about privacy and the prevention of unauthorized access or misuse (Gašević et al, 2023). Ensuring robust data security measures and protecting student privacy is essential to maintaining the integrity of educational processes and maintaining trust.

Another important issue is the risk of bias and discrimination in AI systems (Kizilcec et al, 2022). AI algorithms trained on biased data can perpetuate and amplify these biases, leading to discriminatory outcomes such as biased grades or course recommendations. It is essential to continuously monitor AI models, train them responsibly, and implement measures to reduce bias to ensure equity in educational settings. In addition, concerns about equity and accessibility stem from reliance on AI-powered tools, which can create a digital divide and limit educational opportunities for students from disadvantaged backgrounds, which could exacerbate existing inequalities. Addressing these issues requires a balanced approach that considers ethical implications, promotes equal access, and promotes transparency and accountability in AI-based educational practices.

5. Conclusion

The results of this comparative study on the three types of exams highlight the potential of generative artificial intelligence to improve learning and assessment processes, provided that teachers are closely involved in the process. When AI is used in a complementary way to teachers' pedagogical expertise, as for exam 3, it can indeed promote better performance and deeper learning among students. Teachers play a crucial role in selecting appropriate resources, reviewing the content of assessments, and providing relevant feedback. Conversely, the AI-generated exam without proper supervision, such as exam 2, did not achieve the same levels of success. This highlights the critical role of teachers in guiding and refining the AI generation process so that assessments remain aligned with learning goals. Overall, this study demonstrates that the successful integration of generative AI into education requires a subtle balance between automating tasks and maintaining a central role for the human expertise of teachers. It is on this condition that the full value of this technology can be released to sustainably improve the effectiveness of teaching and learning. To address this, future work aims to develop adaptive-level GAI that can dynamically adjust the difficulty and content of assessments based on individual student performance and learning needs. This approach would allow the GAI system to continuously analyze student responses and automatically adjust the difficulty of subsequent questions in real-time. Challenging questions could be presented to high-performing students to assess the depth of their knowledge while struggling students would receive more scaffolded, lower-difficulty questions. The GAI could also vary the types of questions, mixing in different formats like multiple choice, open-ended, and problem-solving to get a well-rounded evaluation.

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