



Generative Artificial Intelligence: A Revolution in the World of Teaching and Learning

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Abstract

In recent years, education has increasingly moved toward digitalization, with artificial intelligence (AI) emerging as a major innovation for improving scientific and knowledge-based outcomes. Generative AI is widely used in education, medicine, and marketing, and can produce images, videos, designs, and textual content. Applications such as ChatGPT are among the most prominent examples. In education, AI supports lesson planning, educational resource creation, personalized learning, and continuous assessment, while also enhancing critical thinking and problem-solving skills. At the same time, ethical issues such as transparency, privacy, and fairness must be considered. Furthermore, AI improves education quality through digital libraries and innovative resources that enrich teaching and learning experiences and open new horizons for the future of education

Keywords: Artificial Intelligence, Generative Artificial Intelligence, Smart Learning.

I. INTRODUCTION

The field of education has witnessed rapid transformations in recent years as a result of accelerated technological developments, among which the emergence of Generative Artificial Intelligence (Generative AI) stands out as one of the most significant innovations. This technology possesses enormous potential to bring about a real revolution in improving teaching and learning methods. Since its emergence, generative AI has been employed across a wide range of fields, including education, medicine, and marketing, to accomplish numerous tasks such as generating images and videos, producing creative designs, and creating innovative textual content. One of the most prominent and widely recognized applications of generative artificial intelligence today is ChatGPT, which specializes in automatically generating intelligent conversations.

Generative Artificial Intelligence (GenAI) came into the spotlight in late 2022 with the launch of ChatGPT. The rapid growth of AI applications generated significant attention due to their ability to simulate human tasks in producing outputs such as texts, images, videos, music, and programming codes. Today, millions of people use generative AI applications in their daily lives because these technologies offer unlimited possibilities across various domains.

In this article, we aim to explore the role of generative artificial intelligence in education and scientific research through the following elements:

- The importance of generative artificial intelligence.
- A conceptual framework of generative artificial intelligence, including its definition, characteristics, origins, and applications.
- The ethics of generative artificial intelligence.
- The use of generative AI applications in teaching.
- The role of artificial intelligence in the educational process.
- Regulations and guidelines for the use of artificial intelligence in education and scientific research.

1. The Importance of Generative Artificial Intelligence

Generative artificial intelligence is considered a genuine revolution in the field of education, as it opens new horizons for improving the learning experience and enhancing its quality. Through the use of generative AI technologies, educational systems can adapt flexibly to the individual needs of learners, thereby enabling the delivery of personalized educational content that promotes understanding and interaction. Moreover, it contributes to the creation of intelligent learning environments capable of providing diverse educational experiences by offering innovative tools that support both teachers and students, while enhancing the effectiveness and flexibility of the educational process.

In addition, generative artificial intelligence represents a major driving force behind the transition toward self-directed learning, as it provides students with greater opportunities for independent research and exploration. Consequently, it contributes to the development of critical thinking and problem-solving skills. By strengthening the technological capabilities of digital libraries and improving access to knowledge, generative AI also supports the provision of inclusive educational opportunities, thereby broadening access to education on a global scale. Therefore, this field is regarded as one of the future-oriented technologies that will shape the future of education and prepare future generations for active participation in the evolving knowledge society.

2. A Conceptual Framework of Generative Artificial Intelligence

2.1. Definition of Generative Artificial Intelligence

Generative Artificial Intelligence (Generative AI), also referred to as Conversational Computing, represents the application of large natural language models in an increasingly advanced category of interactive interface and shared language tools. It can also be viewed as an extension of human-machine interaction interfaces that evolved from punch cards to Graphical User Interfaces (GUIs) during the previous century.

Generative artificial intelligence refers to a category of AI models and tools specifically designed to create new content such as texts, graphics, videos, music, and programming code. It employs a variety of techniques and methods, including neural networks and deep learning algorithms, to analyze patterns and categories and generate new outputs based on them. Consequently, organizations and individuals, particularly software developers, are increasingly relying on AI tools to create or enhance content, code, designs, and many other forms of digital production.

2.2. Characteristics of Generative Artificial Intelligence

2.2.1. Personalized Learning: Generative artificial intelligence can analyze students' learning patterns and preferences in order to customize educational content and teaching strategies according to individual needs. This, in turn, enhances student engagement, comprehension, and knowledge retention

2.2.2. Adaptive Learning: Generative AI-powered platforms aim to simplify complex lessons and dynamically accelerate or adjust instruction according to students' progress. This ensures that learners receive appropriate support in facing various challenges without experiencing exhaustion, frustration, or boredom.

2.2.3. Design and Multimedia Production: Generative artificial intelligence supports the creation and design of various multimedia resources, including visual and audio materials, among others

2.2.4. Data Analysis: This type of artificial intelligence is capable of processing and analyzing large quantities of educational data in order to identify trends, insights, and areas for improvement. Consequently, it enables educational institutions to make informed decisions that enhance and develop teaching methods and curricula.

2.2.5. Virtual Assistants and Chatbots: AI systems provide instant responses to frequently asked student inquiries, while also offering guidance, counseling, and appropriate support. In addition, they contribute to simplifying various administrative processes such as registration, archiving, and scheduling anytime and anywhere

2.2.6. Education for Students with Special Needs: Artificial intelligence can help identify different learning difficulties experienced by students with special needs and provide targeted measures to support their learning, such as converting written texts into audio formats and vice versa.

2.2.7. Professional Development for Teachers: Generative AI can provide personalized training programs for teachers and contribute to the development of their professional performance based on their strengths, weaknesses, areas of specialization, and interests.

2.2.8. Interactive Analytics: Through predicting students' academic performance and behavioral patterns, AI enables the development of appropriate strategies for rapid and early intervention for learners who may be at risk of academic decline or failure.

2.2.9. Enhanced Research: AI-powered tools can assist researchers in analyzing and processing massive amounts of educational research data quickly and efficiently, thereby facilitating the discovery of insights, theories, and future trends at a faster pace.

2.2.10. Educational Gamification: This is achieved through the provision of educational games and simulations that make the teaching and learning process more engaging and interactive (Al-Qahtani, A. M. M. 2024)

3. Applications of Generative Artificial Intelligence

Generative Artificial Intelligence (Generative AI) is considered a branch of artificial intelligence that focuses on creating new content, whether in the form of text, images, audio, or even video, based on the inputs it receives. This type of artificial intelligence differs from other forms of AI that primarily focus on data analysis or predictive tasks, as generative AI is specifically designed to produce new and original outputs. Consequently, it has become a powerful tool across a wide range of fields and applications.

3.1. Applications for Text Generation and Creation

Among the most important applications are:

3.1.1. ChatGPT: This application operates through interactive conversations with users, where questions and concerns are presented and addressed. One of its most advanced and widely used versions is GPT-4, which generates texts based on textual inputs. This model is capable of writing articles, stories, answers to questions, translations, (Office of the Minister of State for Artificial Intelligence, Digital Economy, and Remote Work Applications. 2023). and marketing content in a natural manner. Through GPT-4, users can simulate smooth and natural conversations while receiving meaningful assistance across a broad range of topics. Moreover, this model is considered one of the latest and most advanced developments in the field of artificial intelligence.

3.1.2. Jasper: Jasper is an AI-powered assistant designed to create business-related content and enrich it with advanced features, including image search, text generation, and idea organization in a manner that aligns with user and organizational requirements. It also offers a free plan for new users with access to some essential features. Jasper is widely used for writing marketing texts, articles, and creative content.

3.1.3. Writesonic: Writesonic is a text-generation tool used to create short written passages as well as creative content for blogs and social media platforms.

3.2. Applications for Image Generation

Among the most prominent applications are DALL·E, Midjourney, Stable Diffusion, Artbreeder, and Craiyon. These tools are capable of generating images from textual descriptions, creating artistic and animated visuals, and producing innovative designs for visual content. They rely on user-provided textual prompts and descriptions to generate high-quality artistic and creative images, including character designs and scene generation. Most of these models are free and open source

3.3. Applications for Audio Generation

One of the most significant applications is VALL-E, a generative model developed by Microsoft that is capable of generating human-like voices based on textual inputs. It is widely used in text-to-speech systems for generating human voices, imitating specific voices, and creating entirely new voice simulations.

Other notable tools include Vocaloid, Murf.ai, and Replica Studios. These applications use artificial intelligence technologies to generate speech and convert text

into realistic human voices. Their free versions generally allow users to experiment with limited features and functionalities.

3.4. Applications for Video Generation

Among the most prominent applications are Pictory, Runway, and Synthesia. These tools provide free services with certain limitations for generating videos from textual content. They can be used to create short video clips based on written text, as well as to edit images and videos.

There are also advanced models such as Sora developed by OpenAI, which can generate promotional or educational video clips and design visual content for social media platforms directly from textual descriptions. Such technologies open new possibilities for the creation of innovative visual content.

3.5. Visual Content Generation Tools (Charts and Infographics)

Among the most important tools is Napkin AI, which offers a free plan allowing users to create visual diagrams and graphical representations based on textual input. This facilitates the simplification of data and the presentation of ideas in a visually accessible manner.

Another widely used tool is Canva, which provides a free plan with a variety of features for designing images, infographics, and presentations using AI-powered tools. Users can benefit from artificial intelligence features such as automatic text generation and innovative image design.

4. Mechanism of Generative Artificial Intelligence

Generative artificial intelligence generally relies on deep neural models, such as Generative Neural Networks and models like Generative Adversarial Networks (GANs). These models learn patterns from input data and utilize them to generate new content that resembles the original data on which they were trained.

4.1. Artificial Neural Networks (ANNs):

Generative AI for text production uses this type of network, commonly known as transformers for general-purpose applications. These systems rely on Large Language Models (LLMs). For this reason, text-based generative AI systems are often referred to as LLMs. The specific type of large language model used in generative text AI is known as Generative Pre-trained Transformers (GPTs). (UNESCO. 2024)

4.2. Generative Adversarial Networks (GANs):

GANs consist of two interconnected components: one responsible for generating content (the generator) and another responsible for evaluating the generated content (the discriminator). The generator aims to create new data, while the discriminator determines whether the generated content is authentic or artificially produced. The generator progressively improves its outputs based on the feedback received from the discriminator. GANs operate by building neural networks capable of generating new data that closely resembles the original training data. For example, when trained on a large dataset of images, the model learns the underlying patterns and can subsequently generate entirely new images with similar characteristics. (UNESCO. 2024)

5. The Emergence of Generative Artificial Intelligence

5.1. Early Generative Beginnings (1960–1990)

During this stage, the earliest attempts emerged to create artificial intelligence systems capable of generating new content, particularly in the field of natural language processing. Among the most notable developments of this period were:

5.1.1. ELIZA: The first chatbot, developed in 1966, which used simple rule-based methods to generate responses resembling those of a psychotherapist.

5.1.2. SHRDLU: A program developed in 1970 that employed natural language interaction within a virtual world composed of geometric shapes.

5.1.3. AARON: A program developed in 1981 that used artificial neural networks to generate digital artistic works.

6. RACTER: A program developed in 1983 that utilized grammatical rules and vocabulary to generate random and incoherent prose texts.

6.1. The Development of Generative AI (1990–2020)

During this stage, the field of generative artificial intelligence witnessed remarkable progress due to the emergence of new technologies such as artificial neural networks, Generative Adversarial Networks (GANs), and transformers. Among the most important developments were:

6.1.1. Generative Adversarial Networks (GANs)

GANs, short for Generative Adversarial Networks, are algorithms developed in 2014 that generate new images by allowing one neural network to compete against another.

6.1.2. Transformers

Transformers are an architectural framework introduced in 2017 that relies on the Attention mechanism to improve natural language processing performance. They were first presented in the landmark research paper *Attention Is All You Need* and rapidly became the dominant architecture for most text-processing applications.

6.2. The Generative AI Explosion (2020–Present)

In this stage, generative artificial intelligence became one of the most prominent fields within AI due to the increasing size and diversity of available data, the growth in computational power and speed, and the enhanced complexity and accuracy of machine learning models. Among the most notable examples are :

6.2.1. DALL·E :

A program launched in 2021 by OpenAI that uses generative techniques to create images from textual descriptions.

6.2.2. Stable Diffusion:

A program launched in 2022 that generates images from textual prompts using diffusion models, which are considered a type of deep generative neural network.

6.2.3. ChatGPT :

A conversational AI system launched in November 2022 by OpenAI, based on an advanced language model optimized for dialogue and capable of generating natural responses comparable to human communication. (Al-Khalifa, H. B. S. (n.d.)

7. Ethics of Generative Artificial Intelligence

These principles, as summarized from UNESCO guidelines, can be presented as follows:

7.1. Transparency: Generative artificial intelligence must be transparent and understandable to the public. The methods of data collection and usage should be clearly explained.

7.2. Fairness: Biases related to race, gender, religion, culture, and social background must be avoided in the development of generative AI systems.

7.3. Privacy: The privacy of users and personal data must be protected, and data should not be used in illegal or unethical ways.

7.4. Responsibility: Responsibility must be taken for the consequences of using the technology, and mechanisms for accountability, monitoring, and evaluation should be ensured.

7.5. Safety: The safety of users and affected communities must be guaranteed, and the use of technology in ways that threaten public safety should be avoided.

7.6. Respect: Different values, cultures, and beliefs must be respected, and the use of technology should not conflict with the ethical and cultural values of societies.

7.7. Diversity: Diversity and inclusion should be encouraged in AI research, development, and governance, ensuring that AI-driven benefits are distributed more equitably.

7.8. Sustainability: Technology should be developed in a way that preserves natural resources and supports sustainable development.

7.9. Humanity: Technology must be developed through a human-centered approach based on human values and rights, avoiding any use that contradicts human dignity and fundamental rights.

8. Uses of Generative Artificial Intelligence Applications in Teaching

Generative artificial intelligence applications have multiple uses in teaching, the most important of which are:

8.1. Creation of Educational Resources

According to the UK Department for Education (2024), the most common use of Generative AI among teachers is the creation of educational resources (62%). Generative models can learn from large datasets of educational materials and design new learning content aligned with educational standards, thereby enhancing diverse and innovative learning experiences.

Generative AI enables teachers to produce customized educational content adapted to different student levels. It can also be used to generate ideas for course topics and activities, design tests and exercises that support learning, and create presentations, course materials, curricula, images, and videos, as noted by Al-Khalifa (2023).

8.2. Lesson Planning

According to the UK Department for Education (2024), 42% of teachers use Generative AI for lesson planning. It can serve as a supportive tool to reduce the time spent on routine tasks such as preparing lesson plans.

8.3. Personalized Learning

Thanks to its ability to learn from student data, generative AI can provide personalized learning experiences tailored to each learner's needs and skills.

8.4. Continuous Assessment

Generative AI can be used to evaluate students' work and provide appropriate feedback. It also helps improve the presentation and delivery of course content in ways that match different learning styles.

8.5. Cognitive Support and Thinking Enhancement

Generative models support out-of-the-box thinking by assisting in brainstorming activities, summarizing and synthesizing complex content, generating questions, and facilitating learning processes.(Waqqad, H. A., et al. (2024).

9. The Role of Artificial Intelligence in the Educational Process

9.1. Improving the Quality of Education (Intelligent Tutoring Systems – ITSs)

Intelligent Tutoring Systems (ITSs) are based on artificial intelligence technologies. They do not only teach facts and knowledge but also help learners develop thinking skills and problem-solving abilities.

Intelligent tutoring systems are defined as: “expert systems in the field of education that rely heavily on extending the teacher’s knowledge and simulating their behavior and thinking processes in solving problems or teaching a specific subject.” The teacher here is considered the human expert in the teaching process, possessing a set of experiences and knowledge related to a specific discipline or curriculum, as well as its teaching methods. By analyzing these experiences and instructional processes, sufficient knowledge can be acquired to develop AI-based training programs (Barsouli, F., & Abd al-Samad, S. (2018).

These systems are based on three main models:

- a. **Domain Model:** represents the learning content and defines what is to be taught.
- b. **Instructional Model:** includes appropriate teaching strategies related to the content.
- c. **Learner Model:** identifies the student, their characteristics, tendencies, and cognitive and intellectual differences.

9.2. Supporting Digital Libraries

A digital library is a system that stores most or all of its collections in machine-readable formats, either as a complement or an alternative to traditional printed materials and microform resources.

The importance of digital libraries lies in their ability to provide access to rare books that are no longer printed, as well as enabling students and teachers to save time, effort, and financial cost while ensuring continuous access to knowledge and information. They also allow multiple users to access the same information simultaneously, meaning that resources can be consulted collectively rather than individually.

Thus, digital libraries aim to organize various types of multimedia and digital resources, provide access to their collections through global networks (directly or indirectly, free or paid), and perform functions such as acquisition, storage, preservation, and retrieval using digital technologies. They also make resources available in a computer-processable format (Abu Asbaa, S. K. (2012)).

9.3. Improving Administrative and Managerial Systems

The automation of repetitive tasks and processes across various fields contributes to faster operations and improved quality. It also enhances employees' ability to perform tasks more efficiently, saving effort and reducing the time required to produce outputs.

Furthermore, it provides an improved and personalized user experience according to the required service, thereby increasing user satisfaction (SDAIA (Saudi Data and Artificial Intelligence Authority). (2023)).

9.4. Enhancing Self-Directed Learning

Artificial intelligence supports learners in developing autonomous learning skills by providing adaptive resources, guidance, and personalized feedback that encourage independent study and continuous improvement.

9.5. Specialized Smart Search in Digital Libraries

Specialized or expert search is one of the most powerful and flexible search options. All search queries are entered into a single dialogue box using command language in tools such as Direct INSPEC. The search scope can be easily limited to specific time ranges or updates using drop-down limit options, and results can be sorted in multiple ways (INSPEC Direct – electronic tool for scientific and technical research).

9.6. Use of Artificial Intelligence to Improve Search Engines in Digital Libraries

Artificial intelligence enhances search engines within digital libraries through the use of technologies such as Machine Learning and Natural Language Processing (NLP). These technologies enable more accurate and efficient information retrieval systems.

AI helps deliver precise and personalized search results based on users' interests and needs, making access to information faster and more effective.

9.7. Enhancing Creativity and Innovation in Higher Education Human Resources

Artificial intelligence plays an important role in enhancing creativity and innovation among higher education stakeholders, including students, professors, administrators, and decision-makers. It helps generate new ideas for products and services and facilitates research and development processes, thereby supporting overall progress (SDAIA (Saudi Data and Artificial Intelligence Authority). (2023)).

Therefore, researchers and users should be encouraged to use artificial intelligence to stimulate personal creativity and generate new ideas, rather than copying or reproducing existing content. In this way, the education sector evolves through the continuous development of creativity among its members.

10. Regulations for the Use of Artificial Intelligence in Education and Scientific Research

10.1. Transparency of Use :

10.1.1. Disclosure of AI Use: Researchers must clearly disclose any use of artificial intelligence at different stages of the research process, whether in idea generation, data analysis, or text writing.

10.1.2. Documentation of Sources and Outputs: If AI is used to extract or generate results, this must be documented in the references section, and the AI tools used must be clearly identified

10.2. Addition of Intellectual Effort and Personal Analysis

10.2.1. Personal Analysis and Critical Thinking : Researchers must demonstrate personal intellectual effort in analyzing and interpreting AI-generated results, rather than merely reproducing them without critical evaluation or added analytical value.

10.2.2. Innovation and Creativity: Scientific research must include the researcher's own creativity and innovation. Even when using artificial intelligence, it cannot replace human creativity in interpreting data or formulating hypotheses.

10.3. Academic Integrity Regulations

10.3.1. Prohibition of Full Research Replacement: Artificial intelligence must not be used in a way that turns research into an automatic compilation of information without intellectual contribution or critical analysis from the researcher.

10.3.2. Plagiarism Prevention: Any use of AI-generated content without proper acknowledgment is considered academic plagiarism and may lead to rejection or disciplinary sanctions.

10.4. Verification and Review

10.4.1. Human Review: Content generated by artificial intelligence must be carefully reviewed and analyzed by researchers to ensure accuracy, with an active role in validating and testing results.

10.4.2. Data Accuracy: Researchers must verify the correctness of AI-generated information and avoid presenting unsupported or unverified findings.

10.5. Education and Training for Proper Use

10.5.1. Ethical Training: Researchers should receive training programs on the ethical and effective use of artificial intelligence, emphasizing research integrity and avoiding full dependence on AI tools.

10.5.2. Awareness of Over-Reliance Risks: Awareness should be raised regarding the risks of excessive reliance on AI in scientific research, which may reduce intellectual effort and academic analysis.

11. Balance Between Tools and Human Effort

11.1. AI as a Supporting Tool: Artificial intelligence should be used as a supportive tool that enhances research work, not as a replacement for the researcher's intellectual effort. Researchers should benefit from AI in accelerating research processes while ensuring that the main work remains human-driven.

11.2. Encouraging Critical Thinking: Researchers should be encouraged to practice independent and critical thinking, even when intelligent tools provide preliminary outputs.

12. Compliance with Ethical and Academic Standards

12.1. Adherence to Academic Standards: Researchers must comply with internationally recognized academic standards, ensuring that AI use respects scientific integrity.

12.2. Intellectual Property Compliance: AI must not be used in ways that violate intellectual property rights or reproduce protected materials without permission.

13. Activation of Legal and Technical Controls for Digital Academic Integrity

Academic integrity in the digital era requires the adoption of effective laws and modern technological systems that align with rapid technological advancements to ensure responsible and ethical use of artificial intelligence (11).

Conclusion

Generative artificial intelligence represents a revolution in content creation. Instead of being limited to data analysis and recommendation systems, it is now capable of generating entirely new content based on user inputs. From text to images and videos, this technology opens limitless possibilities across various fields, including creativity, business, and education.

However, generative AI tools remain dependent on data-driven systems rather than truly autonomous creators. They are not capable of genuine independent innovation. Real innovation comes from the human mind, which plays the central role in linking ideas, analyzing complex phenomena, and producing original insights. Human intelligence remains essential in generating new knowledge and interpretations. Therefore, it is not possible to fully delegate creativity to artificial intelligence.

Accordingly, rational and responsible use of this technological innovation is essential to ensure that it benefits humanity rather than diminishing human cognitive and creative abilities.

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