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Transforming Health Sciences Education through AI

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Abstract

Artificial intelligence has revolutionized several fields, bringing significant technological changes, particularly in health sciences education. As a complex and multidisciplinary field, this discipline involves diverse pedagogical, cognitive, and social dimensions that influence teaching and learning. In this review, we first clarify certain key concepts before examining the potential and challenges of AI integration for both educators and students. The results are promising, and AI opens up interesting perspectives; however, training, particularly in prompt engineering, awareness, and institutional involvement are essential for ethical and responsible use.

I. Introduction

the world has experienced continuous change, marked by significant technological and digital transformation, culminating in the widespread adoption of artificial intelligence [1,2]. Today, artificial intelligence (AI) is an integral part of our daily lives [3], playing innovative roles in fields such as industry, healthcare, education, and many others, directly impacting the general public. It is considered one of the major drivers of socio-economic change[4].Artificial intelligence appears to be a promising approach for health sciences education [5]. The integration of artificial intelligence into higher education dates back several decades. As early as the 1970s, the potential of AI to transform higher education began to emerge with the introduction of computer-assisted instruction, which enabled the development of online learning materials and fostered enriched pedagogical experiences [6]. Higher education subsequently underwent a major transformation with the advent of intelligent tutoring systems. Since then, AI has continued to evolve, with its development marked by numerous technological innovations, including natural language processing models [7]. The main objective of this review is to provide insight into the potential benefits and challenges associated with the implementation of artificial intelligence in the field of health.

II. Historical Background

The concept of artificial intelligence is not recent; it dates back more than 70 years [8]. In 1941, the Bombe machine designed by Alan Turing, which was used to decrypt the codes of the German Enigma machine, represents an early precursor of what is now referred to as artificial intelligence [1]. However, John McCarthy and Marvin Minsky are regarded as the pioneers of artificial intelligence, as they introduced the term for the first time during the Dartmouth Conference in 1956 [9,10].

John McCarthy described the term artificial intelligence (AI) as "the science and engineering of making intelligent machines" [11]. [8] defines artificial intelligence as "Technology that enables computers and machines to simulate human intelligence and problem-solving capabilities." This definition is broad, encompassing applications ranging from GPS systems to autonomous vehicles. [12] proposed a more precise and comprehensive definition: "Artificial intelligence (AI) systems are software-based (and potentially hardware-based) systems designed by humans that, given a complex goal, act

in physical or digital environments by perceiving their surroundings through data acquisition, interpreting the collected data, whether structured or unstructured, reasoning on knowledge or processing information derived from these data, and deciding on the best actions to take to achieve the intended goal. AI systems may use symbolic rules or learn a numerical model, and they may also adapt their behavior by analyzing the effects of their previous actions on the environment."

III. Taxonomy of Artificial Intelligence

Delipetrev et al., (2020) describe three categories of artificial intelligence.

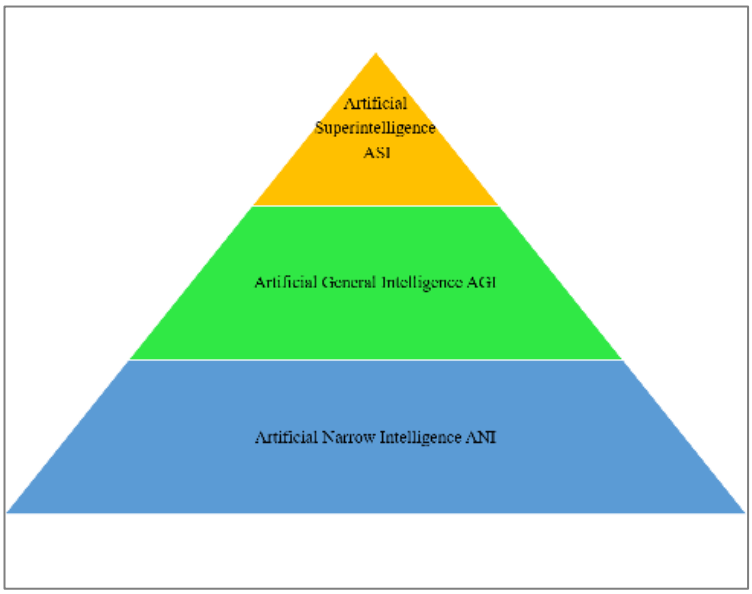

Figure 1: Categories of artificial intelligence.

This classification is therefore based on the scope and complexity of AI's cognitive capabilities[13]:

Table. 1: Detailed overview of the taxonomy of artificial intelligence.

Artificial Narrow Intelligence ANI	Artificial Narrow Intelligence (ANI), often referred to as "weak AI," represents the most prevalent form of artificial intelligence today. ANI systems are designed to perform one or a limited number of specific tasks within a predefined environment. They are particularly effective in executing routine, repetitive, and standardized tasks that humans often prefer to avoid. However, these systems exhibit significant limitations, particularly in terms of their limited ability to generalize beyond the specific context for which they were originally designed.
Artificial General Intelligence AGI	Artificial General Intelligence (AGI), or "strong AI," refers to machines that exhibit human-like intelligence. In other words, AGI aims to perform any intellectual task that a human being is capable of accomplishing. AGI is often illustrated in science fiction films, where humans interact with machines that are conscious, self-aware, and endowed with emotional capacities.
Artificial Superintelligence – ASI	Any intelligence that far surpasses human cognitive performance in virtually all domains of interest." Artificial Superintelligence (ASI) is expected to exceed human intelligence in all aspects, including creativity, general wisdom, and problem-solving abilities. It is assumed to demonstrate forms of intelligence that have never been observed even among the most brilliant human thinkers. Consequently, many scholars and researchers express concern about the potential implications of ASI.

The emergence of AI has been accompanied by the development of two paradigms. [14]

- **Symbolic AI**: relies on the representation of knowledge through symbolic systems and organized structures, primarily using logic to replicate reasoning mechanisms.
- **Sub-symbolic AI**: relies on an implicit representation of knowledge and adopts a connectionist approach. It is mainly based on statistical methods that allow the exploitation of experience or the analysis of raw data.

IV. Key Concepts

- Large Language Model

Large language models have created an exponential shift by demonstrating capabilities close to human understanding. Although their functioning is based on vast training datasets and statistical analysis rather than human-like reasoning, these models can generate responses similar to those of a human interlocutor[15]. In fact, Large Language Models (LLMs) are AI systems built on multilayer recurrent neural networks and trained on extensive datasets to produce text that resembles human writing [16]. For example, ChatGPT (Generative Pretrained Transformer) is a highly popular natural language processing model [7,17], designed to generate human-like content accurately in response to user prompts [18] In November 2022, OpenAI released ChatGPT-3, a free version accessible to the public[19]. However, a paid version with additional features was launched in March 2023 [20].

- Prompt

Prompt optimization in language models improves the quality, accuracy, and coherence of the generated outputs [21]. A good prompt is an instruction written in fluent, grammatically correct natural language and semantically aligned with the research domain, promoting precise interpretation and optimal generation by the model [22] . This would allow for a relevant and efficient use of AI [23]. Current studies further encourage research into the correlation between prompt properties and the behavior of natural language models [24].

V. Technological advances related to AI applicable to health sciences

- Robotics

The integration of robotics into health sciences education enhances the learning experience and helps improve patient safety. Indeed, this technology enables students to transfer their theoretical knowledge into a learning environment that closely simulates the real clinical setting [25]. Moreover, the use of robotic simulators, particularly in surgery, provides learners with a safer, more engaging, and interactive learning experience. [26]

- Machine learning and deep learning

Machine learning and deep learning enable computer systems to improve their performance based on experience gained from datasets, thereby giving them the ability to learn and make decisions autonomously [27]. These technologies offer significant advantages for health sciences education [28]. Based on predictive capabilities, they help guide learners in their training. For example, in ophthalmology, these technologies can assist students in analyzing diagrams, facilitate diagnosis, and support decision-making [29]. Moreover, deep learning and machine learning can even be used to predict students who are likely to experience learning difficulties and to identify factors related to school dropout [25,30].

- Big data

The integration of big data into health sciences education improves teaching practices, promotes inclusion, and guides decision-making. It can be used for the evaluation of educational programs as well as for predicting academic outcomes. This presents significant benefits for academic success [14].

- Immersive technology

The implementation of immersive technology in the field of health sciences is highly promising, as it has made the learning experience more engaging, interactive, and meaningful. [14], This allows learners to transfer the knowledge they have acquired to environments similar to real clinical situations [31]. This technology enables the development of both technical and non-technical skills in learners, which positively impacts learning and academic success [14,25].

VI. Pedagogical benefits of AI in health science education

- For students

Artificial intelligence tools can act as a tutor: they can generate information on various topics and enhance the learning experience for students by helping them manage their time more effectively. They are also capable of planning and preparing assignments, as well as guiding students in conducting relevant research[18]. LLMs can generate relevant learning scenarios, enabling students to understand complex concepts and develop higher-order cognitive skills, such as problem-solving[32,33]

The integration of AI appears promising in the health domain, as it facilitates literature research, provides clinical case scenarios, enhances the learning experience through the simulation of rare clinical situations, and supports clinical reasoning in diagnosis [34,35].

- For educators

AI helps reduce educators' workload [34]. In fact, it holds considerable potential to enhance teaching by enabling educators to identify learners' needs and tailor their instructional methods, thereby optimizing the overall educational experience. LLMs support educational activities by generating lessons and learning objectives, as well as contributing to learner assessment and the design of evaluation tools. Certainly, AI overall enhances the quality of teaching by providing potential for innovation in pedagogical practices [33,36,37]. However, regarding the use of AI, perceptions vary. Some educators express concerns, considering that AI may facilitate cheating, pose risks of plagiarism, and be misused by students [38,39]. On the other hand, some educators encourage the adoption of LLMs, viewing them as promising tools to enhance learning. However, they recommend that the information generated be verified and critically analyzed [40].

VII. Pedagogical challenges of AI in health science education

- For students

LLMs offer significant benefits for learners in health sciences, but their use raises certain challenges and limitations, such as the production of inaccurate information, the risk of plagiarism, and unethical use[18]. However, AI literacy is essential. Students who do not master the creation of appropriate prompts generate unsuitable outputs, which affects the quality of the information produced[41]. Indeed, excessive use of AI can develop a dangerous dependence on these tools, which may affect learners' critical thinking abilities and even the human aspect of care [34,42].

- For enseignants

Although some countries, such as China, South Korea, the United States, Finland, and certain European nations, promote research and aim to integrate AI into learner education by adopting training strategies and providing substantial financial resources for AI development. [14] However, the lack of financial investment by institutions to promote training in this area still persists in some countries [35]. Indeed, for educators, having strong skills in prompt engineering is key to interacting effectively with AI, as it improves performance and helps produce highly relevant outputs.

VIII. Conclusion

Artificial intelligence represents a significant ally in health sciences education. Indeed, the development of standardized guidelines, along with genuine institutional involvement and the advancement of prompt engineering skills, would enable the implementation of targeted training programs for potential users. This approach would allow the full potential of AI to be leveraged while minimizing associated challenges. The ultimate goal is to ensure the ethical, responsible, and thoughtful use of these technologies.

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