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Artificial intelligence in education*

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Abstract

After a brief historical account of artificial intelligence (AI), I provide an overview of the ideas behind AI and the types of AI. Next, I present general ideas regarding the use of AI in education. In addition, I discuss how the problem-solving methods of AI can be used in education. In addition, I discuss the use of modern chatbots in education and I present its pros and its cons. This position paper concludes with some thoughts on Human-Centered Artificial Intelligence, a relatively new trend in artificial intelligence.

Keywords: Artificial Intelligence, Education, Teaching methodologies, Human-centred technology.

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WHAT IS ARTIFICIAL INTELLIGENCE?

Roughly speaking, artificial intelligence (AI) is about machines and systems that exhibit some sort of intelligence, whatever this may mean. Marvin Lee Minsky (1968), an AI pioneer, defined AI as "the science of making machines do things that would require intelligence if done by men." One could argue that AI is the embodiment of the human desire to create machines that can do things that require intelligence, and which cannot be carried out by animals or ordinary machines (e.g., a tractor). Indeed, John MacCarthy (the leading pioneer in artificial intelligence) and Minsky, argued that "any intellectual activity can be described with sufficient precision to be simulated by computer science, electronics, and cognitive sciences" [see (Lexcellent, 2019)], therefore, it made sense, at least for them, to see the emergence of intelligent machines. Furthermore, the Ancient Greeks were the first people who imagined such intelligent machines and who also made some efforts to create such machines [see Mayor (2018) for more details].

Figure 1. The Giant Talos armed with a stone. Silver didrachm from Phaistos, Crete (ca. 300/280-270 BC), obverse (Jastrow (2006), public domain).

Talos (see Figure 1), according to ancient Greek mythology, was a giant bronze man constructed by Hephaestus, the Greek god of invention and blacksmithing. Talos was an *automaton* whose responsibility was the protection of Europe in Crete from pirates and invaders. For this reason, Talos circled the island's shores three times every day. The word automaton (plural: automata) is a word that appears in the Iliad and the Odyssey and describes machines moving on their own by means of internal energy, like living beings [see (Kalligeropoulos & Vasileiadou, 2008) for an overview]. Of course, in the history of mankind there are many examples of automata e.g., tiny singing birds, etc. (see Wikipedia's quite informative article at https://en.wikipedia.org/wiki/Automaton for more details). However, the most notable forerunners resembling what we consider intelligent machines are the "heartless" Tin man from The Wizard of Oz and the humanoid robot that impersonated Maria in the movie Metropolis.

In 1950, Alan Turing tried to answer the question *Can machines think?* by a game which he called an *imitation game* (known as the *Turing Test* now). The purpose of this game was to define a criterion by means of which one could tell whether a machine is intelligent or not. The description of the game that follows is in Turing's own words (Turing, 1950).

> The new form of the problem can be described in terms of a game which we call the 'imitation game'. It is played with three people, a man (A), a woman (B), and an interrogator (C) who may be of either sex. The interrogator stays in a room apart from the other two. The object of the game for the interrogator is to determine which of the other two is the man and which is the woman. He knows them by labels X and Y, and at the end of the game he says either 'X is A and Y is B' or 'X is B and Y is A'. The interrogator is allowed to put questions to A and B… We now ask the question, 'What will happen when a machine [i.e., a computer or a computer program] takes the part of A in this game?' Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between a man and a woman? These questions replace our original, 'Can machines think?'

According to Turing, if the interrogator cannot tell which of the two participants is the computer, then the computer is intelligent. A generalization of Turing's ideas was described by Russell and Norvig (2021) in their famous AI textbook. In particular, they examine what is needed for a computer program to act humanly. They have concluded that a computer must have the following capabilities:

- **natural language processing** to communicate properly in a human language;
- **knowledge representation** to keep somewhere what it learns;
- **automated reasoning** to give answers to questions and to make conclusions;
- **machine learning** to adapt to new circumstances and to see and understand patterns.

A modified version of the Turing test is called the total Turing test, and this requires interaction with objects and people in the real world. A machine can pass the total Turing test if it has

- **computer vision** and **speech recognition** to understand the world;
- **mechanical arms and legs** to manipulate objects and move about.

The goal of (*strong*) AI is to create machines that can think and act humanly. This means that we must understand how humans think. One important aspect of human thinking is that humans are assumed to think rationally and, accordingly, to act rationally. Thus, any intelligent machine must have all these properties and capabilities. However, if we lower our expectations and assume that the goal of AI is to create computers or computer programs able to perform specific tasks (e.g., answering questions based on user input or playing chess), then we are talking about *weak* AI.

Two important sub-fields of AI are machine learning and deep learning. A computer system or a computer program is learning when it improves its performance after making observations about the world. Of course, there is a difference between learning how to play backgammon or when inferring a new theory about, say, quantum gravity. When the system that learns is a computer, then we are talking about machine learning. Deep learning is a special form of machine learning where computation requires many steps when going from inputs (i.e., the data we supply the system) to outputs (i.e., the data the system produces). Deep learning is currently used in visual object recognition, machine translation, speech recognition, speech synthesis, and image synthesis.

DANGERS OF ARTIFICIAL INTELLIGENCE

As with most, if not all, inventions, AI is something that can do good for us but if mistreated it can harm us. The Terminator (See https://en.wikipedia.org/wiki/Terminator) movies are an excellent depiction of a harmful AI. Of course, we are far from this technological advantage, and it is almost impossible to travel in time, as do the characters of the movies. However, the central point of these movies is that computer systems and programs acted unrestrictedly and so they learned and evolved beyond imagination. In the end, the machines became conscious and so, in a sense, they became alive. Currently, we have no idea how to build a conscious machine, so we should not fear that machines will conquer the world any time soon.

This year, Geoffrey Hinton, an AI pioneer, made headlines when he claimed that chatbots (i.e., computer programs that can answer our questions like Amazon's Alexa or OpenAI's ChatGPT) are already tools for misinformation and soon they might pose a risk to jobs (New York Times, 2023a). In addition, he claimed that these systems could be a risk to humanity. Fortunately, or unfortunately, he is not the only one who believes that these chatbots and AI, in general, are dangerous. In addition, prominent figures in the field of AI have expressed their concerns about many different things. For example, as reported by CNN, OpenAI CEO Sam Altman testified before the US Congress on AI risks on May 16, 2023 (Center for AI Safety, 2023). In particular, he said that AI can be used to manipulate voters and target disinformation, thus, influencing the outcome of an election. This is clearly something that should concern all of us as we are living in countries where people elect their leaders and their governments.

If AI is dangerous, how can we be sure that its introduction to our educational systems will be beneficial? The short answer is that cannot be sure, and one might say that it would be better to leave it outside our educational system. However, AI is not only the dangerous chatbots or the vicious robots that want to exterminate us. There are cases where the use of AI in education can be really beneficial, and I am going to discuss and propose completely harmless and quite beneficial uses of AI in education.

EDUCATION AND ARTIFICIAL INTELLIGENCE

Figure 2. A setup of the Towers of Hanoi puzzle.

On May 2029, "*The International Conference on Artificial Intelligence (AI) and Education,"* took place in Beijing, People's Republic of China. In this event, 50 government ministers and vice ministers, as well as around 500 international representatives from more than 100 Member States, United Nations agencies, academic institutions, civil society and the private sector, met to discuss the use of AI in education. The results of the conference were published as UNESCO's digital library document (UNESCO, 2023). Since this was not a purely scientific event, participants discussed general principles and ideas regarding the use of AI in education. The important point is that most nations acknowledge the importance of AI in education.

Recently, the University of San Diego published on their web page an article that described "43 Examples of Artificial Intelligence in Education" (University of San Diego Online, 2023). According to this article, integrating AI in classes can be beneficial. For example, it is very difficult for any teacher in any class to understand what the educational needs of every student in her classroom are, but an AI system can easily adapt to the needs of each student while taking under consideration the strengths and weaknesses of all students. In addition, AI can help teachers identify what students do not properly understand or what they are not aware of and therefore allow teachers to improve their methods and the materials they are using. Furthermore, AI can help teachers to grade exams and create reports about their overall performance. Of course, there are many more examples where AI can help teachers in their work. However, there is something that can really improve the methods employed by teachers---the adoption of AI problem-solving techniques in their teaching.

There are many problem-solving techniques that are employed in AI. However, Nilsson (1971) in his early account of these techniques, used simple problems to demonstrate them. In particular, he used the famous "Towers of Hanoi" puzzle to demonstrate the *problem-reduction* approach. In this technique, we employ operators to transform a *description* of the problem into descriptions of subproblems. To understand the notion of a subproblem, I will first use the description of the puzzle given and then I will explain the subproblems of this specific problem.

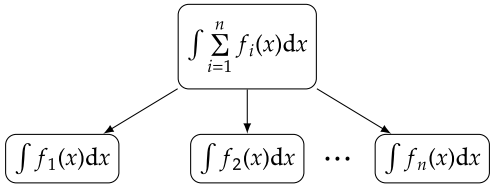
> In the great temple of Brahma in Benares, on a brass plate under the dome that marks the centre of the world, there are 64 disks of pure gold that the priests carry one at a time between these diamond needles according to Brahma's immutable law: No disk may be placed on a smaller disk. At the beginning of the world, all 64 disks formed the Tower of Brahma on one needle. Now, however, the process of transfer of the tower from one needle to another is in mid-course. When the last disk is finally in place, once again forming the Tower of Brahma but on a different needle, then will come to the end of the world and all will turn to dust.

Typically, this puzzle can be solved using a simple problem-reduction approach. If we want to move a tower of height equal to *n* then we can move a tower of height *n - 1* from the first needle to the second, move the last disk from the first needle to the third needle, and, finally, move a tower of height *n - 1* from the second needle to the third needle. Clearly, here the subproblem is to move a tower of height *n – 1* from one needle to another one.

Another problem that can be solved using the same approach is the problem of symbolic integration. In this case, one uses rules of integration to split a problem into subproblems. For example, the *decomposition rule* states.

$$\int \sum_{i=1}^{n} f_i(x)\,\mathrm{d}x = \sum_{i=1}^{n} \int f_i(x)\,\mathrm{d}x$$

Here, the problem is the integration of a sum of different functions, and the subproblems are the integration of each of these functions. The following figure shows exactly how this rule is used.



A problem that can also be solved using the problem-reduction approach is the problem of proving theorems in plane (Euclidean) geometry. We formulate each problem in some "formal" language, define several axioms, and use them to derive a sub-instance of the original problem. This technique really works but one must define his/her formal language so that students have no difficulty understanding it.

ChatGPT is a chatbot developed by OpenAI that can create clear, logical, and convincing essays, solve science and math problems, and produce working computer code. ChatGPT has created panic among teachers, mainly because they are afraid that students will use it to write their assignments and thus pass grades without knowing anything! However, ChatGPT can also be used to evaluate students' papers. Thus, as Kevin Roose (New York Times, 2023b) noted in his New York Times article, "I believe schools should thoughtfully embrace ChatGPT as a teaching aid—one that could unlock student creativity, offer personalized tutoring, and better prepare students to work alongside AI systems as adults." However, not everyone is enthusiastic about ChatGPT and other similar systems. For example, Noam Chomsky, Ian Roberts, and Jeffrey Watumull, argued that a "child's operating system is completely different from that of a machine learning program" (New York Times, 2023c). Therefore, "their deepest flaw is the absence of the most critical capacity of any intelligence: to say not only what is the case, what was the case, and what will be the case—that's description and prediction—but also what is not the case and what could and could not be the case." Despite these flaws, I believe that the introduction of ChatGPT in education will be beneficial for students. For example, non-English speakers can use ChatGPT to learn to write correct texts in English. Since ChatGPT collects huge amounts of data, one can teach students how to *distil* useful information from a heap of information. Also, they can compare their own solutions to problems with the ones generated by ChatGPT. In this case, ChatGPT is assumed to be used as a verification tool. I am sure creative teachers can think of many other uses of ChatGPT.

Figure 3. A picture generated by NightCafe

AI art generators are another type of tool that can be used in education. Users of these tools enter a phrase that describes a scene, then they can fine-tune several parameters, press the create button, and let the generator do its creative work. For example, I have used the NightCafe (see https://creator.nightcafe.studio/) art generator. I entered the phrase "A hare eats carrots near a hole in the ground," changed some parameters, and I got the image shown in Figure 3 in a few seconds. Naturally, these kinds of tools can find many applications in education. However, the most important thing is that it allows students who are lousy drawers (I am one!) to create real masterpieces.

Shneiderman (2022) presented what he calls Human-Centered AI (or just HCAI). It seems that he is the one who coined the term and introduced the relevant ideas. However, Bingley et al. (2023) is a group of people that have explored, in their own words, to what extent the human is in HCAI. Note that the goal of HCAI is to change the focus in AI development form technology to people. Unfortunately, we do not really whether the principles and practices used today can lead to the achievement of this goal. Thus, Bingley et al. (2023) conducted a survey among developers and users and concluded that "an increased focus on what people need in their lives is required for HCAI to be truly human-centred." I think that education can also play an important role here. More specifically, educators, schools, and AI developers can collaborate to create applications and tools that would really belong to HCAI.

DISCUSSION AND CONCLUSION

I have briefly introduced the concept of AI and I have outlined its pre-history and its history. Next, I presented my views regarding the dangers of AI and then I discussed the use of AI in education. In particular, I suggested that the various problem-solving techniques employed in the development of AI applications and tools can be used to teach students how to solve problems. Also, I discussed the use of chatbots and AI art generators in education. Next, I introduced HCAI and suggested its use in education.

All the methods employed in AI to solve problems have been designed to train a completely dummy machine. And in many cases, these methods have been proven to be quite successful. Clearly, this means that one can use these methods to teach problem-handling and solving to individuals who are intelligent but not so knowledgeable. In general, AI can be used to develop critical thinking and problem-solving skills. However, it is crucial not to rely on AI to develop these skills but to use the approaches taken to handle and solve problems to develop these skills. This clearly is a big difference. Despite many concerns, intelligent chatbots in the classroom can be very beneficial (Stanford Graduate School of Education IT Teaching Resources, 2023). Thus, any school can use these tools and the method discussed above to develop a modern curriculum, wherever this is possible, or, more generally, to demand a change of the curriculum, wherever a central curriculum exists. I strongly believe that new teachers must be proficient in the methods used to solve problems in AI and the use of modern tools. All in all, the school of the future is a school where AI plays a central role in teaching and the development of key skills.

Statement of Researchers

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