

The Impact of Artificial Intelligence on Education

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ABSTRACT¹

The advancement of artificial intelligence (AI) technology has greatly impacted our daily lives. Generating a video from a text description used to be difficult, if not impossible, but has now become possible. After ChatGPT became viral after its first official release in December 2022, the development and usage of AI has increased rapidly. As large language models (LLMs), the backbone of current generative AI (GenAI) systems, has become available as open source, the creation of a local AI has become an easy task. Local AI can solve some of the concerns of personal privacy issues. As we embrace this technology, we investigate the most recent AI technologies and their impact on education in this report. There are both positive and negative impacts when AI is used in education. We will discuss how recent technologies may be used to alleviate the negative impacts. We also discuss the challenges faced by educators today.

Keywords: LLM, AI, Education, RAG, Fine Tune, GenAI.

1. INTRODUCTION

Technological revolutions always impact our life [1]. Sometimes, just one new invention can cause great changes. For example, the steam engine invented by Thomas Newcomen, James Watt and Matthew Boulton impacted society greatly. As described in [2], *'Watt later collaborated with Matthew Boulton to invent a steam engine with a rotary motion, a key innovation that would allow steam power to spread across British industries, including flour, paper, and cotton mills, iron works, distilleries, waterworks and canals.'*

Human civilization can be described using words (a combination of character symbols) in languages, images, audios, and videos. For example, a history textbook is a combination of words and pictures. If we can process languages, images, audios, and videos on a computer, then we can process our human civilization by using computers. Computers can process data to generate information. The output of the processing of information gives us knowledge. Knowledge is very important for us and can help us make informed decisions.

After ChatGPT became viral in December 2022, AI applications increased in popularity. Students started using ChatGPT to find the solution for their assignments. According to Pew Research Center survey [3], about 1 in 5 U.S. teens who have heard of ChatGPT have used it for schoolwork. A survey of 1,000 U.S. college students found that nearly a third of them had used the AI chatbot ChatGPT to complete written homework assignments, and close to 60 percent use it on more than half of their work [4].

Why GenAI is useful and important? There are many professions that can be described as generators that generate words, symbols, pictures, images, or videos, or the combinations of these. For example, authors write articles and books, while storytellers write and tell stories. An artist creates works of art, architects draw blueprints, and filmmakers create images and audio in the form of videos. Programmers write program code. So GenAI is tool that these professionals can use to transform their ideas and thoughts into a final product.

Although ChatGPT has been widely used to help people do things more easily, there are major banks which have restricted their employees from using ChatGPT, like Goldman Sachs, Bank of America, Wells Fargo, JPMorgan Chase, Deutsche Bank, and Citigroup [5, 6, 7, 8]. The main reason behind this decision is because by law, financial institutions have a responsibility to protect sensitive business information due to privacy concerns. Although they restrict the usage of ChatGPT for their employees, these banks develop and provide proprietary AI assistants for their customers.

Some institutes embrace this technology and even create tools to help students to pursue excellence. For example, Carnegie Mellon University provides guidance and resources for students to use in their job search process. It recommends and encourages students to use various resources such as a personalized resume AI called Vmock to help student to optimize their resumes, a job recommendation system called Handshake, and an interview video processing AI that provides immediate feedback and coaching [9].

At least 22 states and their Departments of Education have official guidance or policy on the use of AI in K-12 schools [10]. We expect that in the future, more state governments and even the federal government will offer guidance, policy, and instructions about AI in education.

Since AI is a tool, we should be educated to use it skillfully and responsibly. We trust the government will regulate the usage of AI so that it is used in a safe, secure and ethical manner. As the saying goes, with greater authority comes greater responsibility. The future generation of citizens should be educated not only in the skills of using AI, but also how to use it properly. It is up to the educators to ensure that this happens.

AI literacy will become important as AI becomes more widely used. Designing AI curriculum in K-12 schools should be considered as soon as possible. It may be beneficial for AI education to be included into the high school curriculum across the United States, and all should understand the power, weaknesses and limitations of AI technology.

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2. RECENT DEVELOPMENTS IN AI TECHNOLOGY

The ultimate goal for the AI research community is to create a tool which is so powerful that it can do anything that humans can think of. However, the reality is that there are times when AI gives us wrong answers or even unrelated answers, also known as AI hallucination. To improve it, RAG, instruction tuning, and agents are proposed to solve the problem as the solutions for the transition period before we reach the perfect general AI. In this section, we will briefly introduce some of the technologies being used to ensure good AI performance.

2.1 LLM: token, layer, parameter, and dimension

A LLM is a neural network. A neural network has input layer, hidden layer and output layer. Different LLMs will provide different dimensions, context length, parameters and layers. The number of inputs to a layer is known as the *context length*. It denotes the number of inputs that can be input to the network simultaneously at a layer. For LLM, we call each input to a layer a *token*. Usually, we call the number of inputs to a network as its *context length* or *context window*. For example, if network can handle 128,000 tokens, then its context length is 128,000. Between two layers, there are many interconnections. Each connection between two neurons has a number associated with it. That number is called a *weight*. In the LLM models, weight is called *parameter*. Because LLMs have many hidden layers (very large and deep network), therefore it has many parameters.

For example, GPT-3 can handle 2048 tokens, Mistral 7B context window is 8192 tokens, GPT-4o can handle from 60K to 128K tokens in some configurations, Claude 3.5 has context length of 100K tokens, LLama 3.1 can handle 128K tokens, and Gemini 1.5 Pro is 1M tokens. A bigger context window length allows the LLM to process bigger input text, and it will generate more accurate and more contextually relevant responses [11].

The data used in training LLMs are in the magnitude of trillions. The data need to be processed before they are fed into the LLMs. Different models of large language will treat the data differently.

Each word is embedded as a vector. An embedding is a numerical representation of a piece of information. Examples include text, documents, images, audio, etc. Text embedding translates a word into meaningful numbers. The resulting numbers (a list) are deterministic and carry meaning, so the vector (the numbers) is also deterministic and carry meaning. It uses hundreds or thousands of numbers to represent a word like 'dog'. The number of numbers used to represent a token is called its *dimension*.

In [12, 13], the davinci-001 has dimensions of 12288, while OpenAI released a shorter version of 1536 dimensions (1/8 times in size) in December 2022. Therefore, a token will be represented as a vector of 12288 numerical numbers for the original davinci embedding and 1536 number vector for the version 002. The main reason is to reduce the computational cost. If we compare the memory size required to hold the tokens of size 10 million, 1536-dimension vector requires 3 Giga bytes of memory and 24.576 Giga bytes of memory using 2-byte float number. If four bytes are used to represent a number, then the size will double. To alleviate the main memory requirement, one can reduce the size of the number from 2 bytes to 1 byte, but the performance may suffer.

GPT-4 has 120 layers with 1.8 trillion parameters. GPT 3.5 has 96 layers, number of parameters is 175B [14]. LLama 3.1 has 126 layers and 405B parameters [15]. Gemini 1.5 Pro has 1.5 trillion parameters. Note that the parameter consists of weights and bias. Bias is a constant which helps the model in a way that it can fit best for the given data. It is used to affect the activation function of the neural network.

2.2 Generative AI

GenAI is a type of narrow or weak AI that can generate new content, such as text or images, in response to a prompt. The content generated is based on the content it has been trained on. Examples of generative AI systems include: AI chatbots such as OpenAI's ChatGPT, Google's Gemini, GitHub's programming AI system Copilot, and art creator Midjourney. Generative AI is a subset of deep learning. Deep learning mimics the human brain to create artificial neural networks. The most famous architecture used in AI is called transformer architecture. A transformer has encoder and decoder. The transformer is a deep learning architecture developed by Vaswani et. al. at Google. It is based on the multi-head attention mechanism, proposed by the famous and important paper "Attention Is All You Need"[16].

2.3 RAG

RAG stands for Retrieval-Augmented Generation. The famous paper of Patrick Lewis outlines the RAG structure [17]. It combines two models together, the retriever model and a generative model [18]. Domain related data or documents are chopped into chunks and each chunk will then be tokenized. Each token is embedded as a vector. These document chunks are then stored into the vector store. User can enter query and the query is encoded and used to search the vector store to retrieve relevant document chunks. For example, if our domain is 'Python Programming Language' and if a user wants to know about a Python list, the query will be embedded and some kind of similarity checking, like cosine similarity, will be performed to find the document chunks with the best fit. These document chunks will then be used along with the user query be input to the generator (transformer) to generate the output.

2.4 Instruction Tuning

Instruction tuning is supervised learning. As mentioned in [20], instruction tuning is described as 'a technique for fine-tuning LLMs on a labeled dataset of instructional prompts and corresponding outputs. It improves model performance not only on specific tasks, but on following instructions in general, thus helping adapt pre-trained models for practical use.' [19] gives a recent survey about the use of instruction tuning to fine tune LLMs.

2.5 Fine Tuning

Fine tuning is used to train the pre-trained LLMs with a smaller, domain-specific dataset to use for that domain [21]. The main purpose of fine tuning is for that particular application to achieve the maximum performance.

[22] outlines the difference of fine tuning and instruction tuning. Both tuning methods are for adapting LLMs for real world applications.

2.6 Agents

Agents are also known as experts, since they excel at handling specialized work efficiently and accurately.

An AI agent is a program that can execute specific tasks automatically. It can gather essential data, retrieve necessary information, collaborate with other agents, or make reasoning, direct other agents to fulfill the goal(s) which are set by the user. The user can be a human user or another agent [23, 24, 25]. For example, in the financial application, Han et. al., presented a novel multi-agent collaboration system designed to enhance decision-making in financial investment research [26].

Zhou and Yang et. al., proposed a platform that supports multiple financially specialized AI agents that integrate both quantitative and qualitative analyses to emulate the comprehensive reasoning of a human analyst [27, 28].

2.7 The importance of data used for training

LLMs are pre-trained neural networks. The data used to pre-train the networks will affect its generative output, because 'garbage in, garbage out'. A person often bombarded by and immersed in harmful ideas is likely to develop harmful ideas themselves, whereas a person raised and trained under a healthy environment will more likely develop healthy and 'good' ideas. The 'goodness' is defined by culture and generation. Selecting high quality data to train a neural network is similar. Just like a good medical school will greatly help students to become a good doctor, 'good' input data will help the outcome to be 'good'. Once again, it depends on how you define good. The data used for training greatly determines what kind of AI it will be. AI itself is neutral – it is neither evil nor good. It is really dependent on the data used to train them by the trainer (the programmer). To use a simple example, students are taught at school to be respectful to others, and not bully fellow students or teachers. So why do some students still bully others? It is often because students receive other sources of input that may be considered 'wrong', 'harmful' or 'unhealthy', and they are 'trained' by the information that they receive from those other sources.

3. POSITIVE AND NEGATIVE IMPACTS IN EDUCATION

In this section, we discuss the positive and negative impacts of AI on education.

3.1 Possible positive impacts of using AI

3.1.1 Personalization and flexible curriculum

An AI teacher can serve the role of a personal tutor. It can give students real-time feedback [24, 27]. It can tailor curriculum content based on students' assessment results and needs, or even on their preferences, i.e., AI teachers can adjust course content based on individual progress and level of competence. For example, an AI teacher that teaches elementary school students will be different from one that teaches high school students. As AI excels at numbers and statistics, using AI to identify students' knowledge levels is easy. In addition, AI can figure out students' learning obstacles and where students are struggling, and teach them individually in those areas. The other benefit is that students may learn according to their own pace and therefore reduce the

anxiety of students who need additional time to learn the material, and at the same time, save time for students who already demonstrate understanding of the material.

AI also excels at language processing, so a well-designed curriculum can be easily translated to other languages to allow users who may prefer different languages the choice to maximize and enhance their learning experience. In this way, an AI teacher may communicate more effectively and efficiently than a human teacher.

3.1.2 Equality

Often, we wonder if education is just for those who are wealthy. Has education gradually become a privilege and not a basic human right? There are students who live in remote areas or poor countries. How do we provide equal opportunities to them? Because AI tools are virtual resources, students in poorer countries can still have access to good AI teachers and therefore be offered quality education, provided that internet access is available. In addition to the equal accessibility, AI can find the best and most appropriate materials for students according to students' knowledge level. For people in certain countries, education is only way for a person to escape from poverty. The equal access of education will break inequality and make the world a better place to live.

3.2 Possible negative impacts of using AI

3.2.1 Privacy

AI systems often rely on vast amounts of data. Most high-tech companies collect users' data so that they can profile them. The collection and utilization of such data raise questions about data privacy and security. There is the risk that some sensitive data could be shared without student's consent, especially if these students are minors. How do we protect them? If there is no mechanism provided to protect student privacy, would that impact students' willingness to express their ideas and thoughts, or hinder students from expressing their creative ideas? In most social networks and websites, individuals can decide to opt out of data collection. Some schools, such as CMU [9], will not collect a student's data if the student uses their ID to login into the AI system. But what about when an AI tool being used is not easy to opt-out? For example, if a facial recognition system is used, it is very difficult for a student to opt out because most of today's video systems cannot simply erase just a specific person from the video easily. The question is, when can technology advance in such a way that it will automatically erase someone in the system if there is a user demand to opt-out?

3.2.2 Isolation

The intensive use of AI may cause loss of personal touch and connection [29]. If systems can automate tasks such as grading, feedback generation, and content delivery, would it reduce the role of teachers and limit the opportunities for interaction with fellow students? There are two scary thoughts: 1) How will society handle a large number of teachers being unemployed? and 2) In the future, will we need as many human teachers as we have today?

3.2.3 Cheating and plagiarism

Students can use AI to cheat in assignments or exams [30]. Assessments are given by teachers to evaluate individual students, not machines. As discussed earlier, the use of AI such as ChatGPT to do homework has become increasingly popular. The challenge is, how can a teacher maintain the integrity of a fair grading system? The second question is: how do we enforce academic integrity? Researchers using various methods to detect plagiarism. For example, Kundu et al. proposes a keystroke dynamics-based method to differentiate between genuine and assisted writing within academic contexts [31].

3.2.4 Loss of creativity and diversity

There are many disciplines that are considered art. Even writing software is considered as a state of art, because different programmers can implement code in various ways. Using AI might promote uniformity view (depending on the data). Therefore, it may limit diverse perspectives and views. Another negative impact is it may suppress or kill creativity. The question is: who decides whether an idea is good or bad, or if a piece of literature is good or bad writing, or if a piece of art is a good or bad painting?

3.2.5 Bias

AI systems were built using data to train its model. If data has bias, then AI will have bias as well [32]. The question we are facing here is: how do we remove or reduce bias, inequalities, and discrimination? In [33], Malmqvist proposed using methods of improved training data, novel fine-tuning methods, post-deployment control mechanisms, and decoding strategies. Concerned about improved data, the question is: What is considered good data or bad data? Who decides good vs bad? If the person who decides what data to use has bias, then the data still has bias.

3.2.6 Dependency

When students find that AI is useful in their coursework, would that cause students to become totally dependent on AI tools? What would be the long-term effects of students always relying on AI? The other question is: Would heavy reliance on AI in education hinder development of critical thinking skills and problem-solving abilities for our next generation of students? I.e., would AI cause students to think less? [34] described an experiment which was conducted by Professor Klopfer of MIT. He divided the class into three groups and gave them a programming task to solve in the Fortran language, which none of them knew. Group 1 was allowed to use ChatGPT. Group 2 used Meta's Code Llama LLM. Group 3 could only use Google. Group 1 solved the problem quickest while Group 3 took the longest time because they had to break the task down into components. Group 2 was in the middle. The students were then tested on how they solved the problem from memory. Group 1 remembered nothing, and they all failed. Half of Group 2 passed the test. Every student in Group 3 passed. What an experiment! This illustrated that hard work and intensive thinking, as well as critical thinking, is very important in education.

4. CHALLENGE TO EDUCATORS

The fast advancement of AI technology imposes a great challenge to educators and government. Below we list and discuss some challenges that educators are facing.

1. Will students become more intelligent or less intelligent if AI is used in education?

Internet addiction has become a problem for students. Many students spend increasingly more time on social networks such as TikTok, YouTube, Facebook, IG, etc. Time is limited to 24 hours a day, so if a student spends much time socializing with peers, then they have less time for studying. If students are using ChatGPT to generate assignment solutions due to lack of time, then the question is: would the use of AI to complete homework assignments make a person more intelligent or less intelligent? This is hard to determine, so the challenge for educators is: how can we ensure students learn and become more knowledgeable and more intelligent when AI is involved in education?

2. Can we end up with a better society if AI is used in education?

People usually tend to follow the majority, but the majority is not necessarily always right. Internet does contain fake news, false knowledge, bad ideas, etc. Since AI uses Internet data to train its model, the model will exhibit bias if the data used has bias.

Because AI just consists of algorithms that lack human nature and don't have human emotion or sensation, it is possible that bias, discrimination, injustice and inequalities may occur. So, the challenge for social and humanity educator is: how can one ensure the use of AI will direct our students to pursue a more righteous, just, and fair society, which will eventually point to a better society for all human race?

3. How can educators control AI and make sure it is just a tool and not the master?

From my experience as an educator, I have found that students have a tendency to find an easy way out. For example, given the choice between a difficult project or easy project, most students will prefer the easy project. Computers can help do things more quickly, even the things that we already know how to do. For example, finding details about a historical event, designing a vacation plan, helping to write a program code more quickly. Would the use of AI tool generate a mentality of dependency where individuals always ask AI to do things for them?

As discussed earlier, the agents that companies and researchers are developing now are autonomous. Is it right to ask AI to come up with a better structure of human society, or to create a new law which governs our society? Is it acceptable to ask AI to come up with a way to redistribute resources among people? Is it safe to allow AI have its autonomous consciousness? The argument is, if AI can make decisions to take actions without human permission, then who is the one in charge and who is merely the tool? Who is the owner using the tool? If we allow AI to have its own 'personality', would AI want to become the leader and decision maker, rather than the tool that helps make decisions?

If AI is a tool, then humans should have ownership and authority to make decisions. The challenge to us is, how can we ensure that AI will only be a tool?

According to IMF, 40% of global jobs are being impacted by AI [35]. Huang says in [36], “Depending on the jobs we do, it (AI) could do 20% of our jobs 1000 times better...”. Huang warned against the competitive edge gained by those who effectively utilize AI tools. “The real threat,” he cautioned, “is that the person who uses AI to automate that 20% is going to take your job.”

If the AI age is coming and is inevitable, then forbidding students from using AI tools could mean losing a competitive edge over others in the work force. Instead, educators should embrace AI and embed AI into the curriculum as quickly as possible so that our students can learn how to use these tools correctly and meet the challenges of the future world. Educators should teach what the students need or what industries look for, and not just the technologies that the professors themselves are familiar with. With that being said, educators should be familiar with AI tools so that we can better prepare students to meet the challenges of the future they will face.

According to [37], *‘The function of education, therefore, is to teach one to think intensively and to think critically’*. *‘We must remember that intelligence is not enough. Intelligence plus character—that is the goal of true education.’* According to [38], there are four purposes for education: 1) Personal: Education should enable young people to engage with the world within them, as well as the world around them; 2) Cultural: Schools should enable students to understand their own cultures and to respect the diversity of others; 3) Economic: Education should enable students to become economically responsible and independent; 4) Social: Education should enable young people to become active and compassionate citizens.

Educators have established different pedagogical approaches to teaching our students. As AI subverts our ideas and affects our existing and established curriculum, how do we adapt a new approach and modify, if not totally redo, our existing pedagogical method to adjust to this new challenge?

Based on the understanding of AI fine-tuning, we think the best way for an educator to equip themselves is to create their own AI tool in their teaching. For example, with RAG, an instructor can put all the ‘best materials’ that they know into the database so that student can use it to find useful information according to the instructor’s philosophy and will. The byproduct of RAG is the instructor can embed the classroom rule, policies and regulations into the database so student can find requirements and information like exam dates, topics covered etc. As this information can be modified or updated dynamically and easily, it will save instructors time and allow them to concentrate more on pedagogic design of the curriculum. Instruction tuning can also be used to fine tune the system. We think the best format may be in the form of questions and answers. These Q&As can be placed in a hub for all the instructors in that field to share. As for the STEM educators, AI agents should be created and shared so that the computation questions related to mathematics can be easily performed.

In the area of STEM education, the educator should emphasize critical thinking and intensive thinking. Rather than just focusing on know-how, we can do more. We should encourage and direct students to fully understand the solution given by AI. By encouraging students to ask why and what, rather than just how, we can help STEM students become a more productive individual. Most LLMs allow the system to output the inference

steps. Although the information from these inference steps can be improved, we believe it will be done by the research community quickly. Instructors should ask students to understand the reasoning behind the answer given by AI. After all, the ‘why’ may be the most important factor to inspire a student to become a great scientist.

Because AI is a tool, educators must ensure that students know how to use these tools in a responsible and ethical way. As Martin Luther King Jr. said, education is intelligence plus character [37]. Knowledge can be used for good or evil. While intelligence is important, the character and morals of the individuals who use that intelligence may be even more important than the intelligence itself.

5. CONCLUSIONS

In this report, we investigated the recent developments of AI technologies and their potential impact on our society, focusing especially on how these technologies impact the current education systems. There are positive impacts and negative impacts. By looking into these technological developments, we discussed how educators can adjust their instructional approach to best teach students. By creating local AI tools dedicated for particular subjects, the curriculum can be tailored in a more creative way. The adoption of AI technology into our curriculum needs to be done in a way that circumvents and avoids the negative impacts of AI tools, while enhancing and improving our education at the same time.

Since the coming of the AI age does not only affect our educational system but also the whole society, the impact of AI systems on society will trigger the government to take swift response. The response from the government may involve new laws, policies, regulations, and guidance. All these can be embedded into our educational curriculum so that we can prepare the next generation to meet the challenges of the future world. After all, whoever controls the AI technology will control the direction of the world. Are we ready?

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