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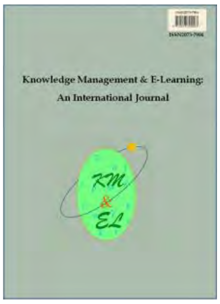
Chenjia Zhu
The University of Hong Kong, Hong Kong
Meng Sun
Jiutong Luo
Beijing Normal University, China
Tianyi Li
Nanjing University of Science and Technology, China
Minhong Wang
The University of Hong Kong, Hong Kong



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How to harness the potential of ChatGPT in education?

Chenjia Zhu

Faculty of Education
The University of Hong Kong, Hong Kong
E-mail: ivyz@connect.hku.hk

Meng Sun

College of Education for the Future
Beijing Normal University, China
E-mail: msun@bnu.edu.cn

Jiutong Luo

Center for Educational Science and Technology
Advanced Innovation Center for Future Education
Beijing Normal University, China
E-mail: jtluo@bnu.edu.cn

Tianyi Li

School of Energy and Power Engineering
Nanjing University of Science and Technology, China
E-mail: litianyi@njust.edu.cn

Minhong Wang*

Faculty of Education
The University of Hong Kong, Hong Kong
E-mail: magwang@hku.hk

*Corresponding author

Abstract: Technological advancements, particularly in the field of artificial intelligence (AI) have played an increasingly important role in transforming education. More recently, ground-breaking AI applications like ChatGPT have demonstrated the potential to bring radical changes to the educational landscape due to their capability to understand complex questions, generate plausible responses and human-like writing, and assist with the completion of complex tasks. However, ChatGPT has limitations in the quality of its output, such as the inclusion of inaccurate, fabricated and biased information and the lack of critical thinking and in-depth understanding. The combinations of these capabilities and limitations along with external factors (e.g., the growing demand for personalized learning support, the irresponsible and unethical use of AI) presents a range of opportunities and challenges to the potential use of ChatGPT in education. This paper presents a thorough SWOT (strength, weakness, opportunity, threat) analysis of ChatGPT, based on which we propose how ChatGPT can be properly integrated into teaching and learning practice to harness its potential in education.

Keywords: ChatGPT; Education; Artificial intelligence; SWOT analysis

Biographical notes: Miss Chenjia (Ivy) Zhu is a Ph.D. candidate at the University of Hong Kong, focusing on technology-integrated learning and educational psychology. She is an alumna of the University of Melbourne, where she earned her bachelor's and master's degrees before pursuing her doctorate. Her current research focuses on the integration of generative artificial intelligence in educational settings, aiming to develop a deeper understanding of its impacts on teaching and learning processes.

Dr. Meng Sun is a lecturer/assistant professor in the College of Education for the Future of Beijing Normal University in Zhuhai, China. Her research interests include technology-supported thinking and learning, scientific creativity, and AI in education.

Dr. Jiutong Luo is a Postdoctoral Research Fellow affiliated with the Center for Educational Science and Technology of Beijing Normal University in Zhuhai, and the Advanced Innovation Center for Future Education at the Faculty of Education of Beijing Normal University in Beijing, China. His research interests include educational technology and psychology, ICT in education, and cognitive neuroscience.

Mr. Tianyi Li received his bachelor's and master's degrees in weapons launch engineering from Nanjing University of Science and Technology. Now he devotes himself to teaching foundational mathematics courses in colleges (e.g., calculus, linear algebra, statistics) and researching how to improve the teaching process. He posted free math lessons on video websites and has gained over 750,000 subscribers.

Dr. Minhong (Maggie) Wang is Professor and Director of the Laboratory for Knowledge Management & E-Learning in the Faculty of Education, The University of Hong Kong. She is also Eastern Scholar Chair Professor at East China Normal University and Visiting Research Professor at the Advanced Innovation Center for Future Education of Beijing Normal University. She is the Editor-in-Chief of Knowledge Management & E-Learning (indexed in Scopus & ESCI). Her research focuses on learning technologies for cognitive development, creative thinking and complex problem solving, knowledge management and visualization, and artificial intelligence applications. She is recognized as ESI Top 1% Scholar in (a) Social Sciences, General, and (b) Economics & Business. More details can be found at http://web.edu.hku.hk/staff/academic/magwang.

1. Introduction

Advances in technology particularly in the field of artificial intelligence (AI) have been changing the world in a variety of ways. AI, the simulation of human intelligence processes by machines or computer systems (e.g., expert systems, natural language processing (NLP), facial recognition, chatbots) has been successful in solving a wide range of complex problems, such as medical diagnoses, fraud detection, processing loan applications, and driving vehicles to name a few. In the past three decades, AI-based applications have been increasingly used in education settings, for example building intelligent tutoring systems to provide personalized learning materials, guidance, and feedback to learners.

More recently, the application of AI in NLP has resulted in the creation of intelligent chatbots and virtual assistants that can understand human language and facilitate human-like conversations (Caldarini et al., 2022). This sub-field, known as generative AI, focuses on rapid generation of realistic outputs (e.g., ideas, reports, scripts, programming code) in response to user requirements. One of the prominent generative AI tools is ChatGPT (i.e., the acronym for Chat Generative Pretrained Transformer) developed by OpenAI (https://openai.com). ChatGPT is built on a cutting-edge language model and trained on a massive dataset using deep learning techniques – these methods allow it to capture a wide range of linguistic patterns and relationships, and thereby understand user input in natural language and generate seemingly credible responses in human language within seconds (Caldarini et al., 2022; Wang et al., 2023).

Since its release in November 2022, ChatGPT has gained growing popularity among the public as marked by a rapidly expanding user number and the predominantly positive public discourse heightening enthusiasm on social media platforms (Tlili et al., 2023). ChatGPT has shown superior performance in understanding complex questions, producing plausible answers in real time, generating coherent and informative writing, and providing instructions or solutions for complex tasks. It holds immense potential to offer a multitude of applications in both work and life settings. For instance, ChatGPT can be employed to draft emails, generate reports, and create content that is increasingly indistinguishable from human-generated material (Abdullah et al., 2022).

In the educational sphere, ChatGPT has attracted widespread attention due to its capability mentioned above. Public discourse on social media reflects a positive sentiment and a growing enthusiasm for integrating ChatGPT into different educational environments. The discussions triggered a lot of debates as well. Many scholars have written about potential benefits and negative effects as well as various concerns regarding the integration of ChatGPT into education in different disciplines (Arif et al., 2023; Farrokhnia et al., 2023; Gilson et al., 2023; Lo, 2023; Mhlanga, 2023; Rospigliosi, 2023; Rudolph et al., 2023; Thurzo et al., 2023; Tlili et al., 2023).

While the introduction of ChatGPT into education has sparked a lot of debates, there is an inadequate discussion on how the potential of ChatGPT can be harnessed in education by maximizing its benefits and minimizing negative consequences. It is essential to understand how AI works as well as its capabilities and limitations and thereby promote responsible and effective use of AI in education with a view to navigating the ubiquitous and rapidly changing technological environment. To this end, this paper presents a thorough SWOT (strength, weakness, opportunity, threat) analysis of ChatGPT, i.e., analyzing the main strengths and weaknesses of this cutting-edge AI technology as well as external factors that present opportunities and threats to its use in education; based on the analysis, we propose how ChatGPT can be properly integrated in teaching and learning practice to realize its potential in education.

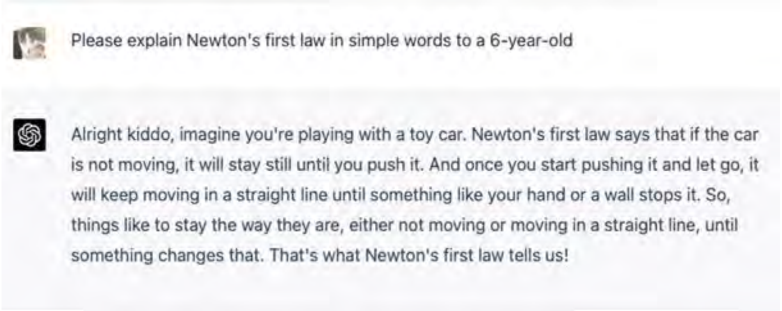
2. SWOT analysis of ChatGPT

2.1. Strengths of ChatGPT

ChatGPT is an advanced combination of deep learning, natural language generation, and dialogue management techniques, making it distinct from existing AI technologies (Abdullah et al., 2022). The key aspects of its benefits are outlined as follows.

Generating plausible responses to questions in human-like conversations. Owing to its robust NLP capabilities, ChatGPT can process and respond to user questions and follow-up questions in an intuitive and user-friendly manner and generate human-like responses tailored to the context and content of the user's query (Abdullah et al., 2022). It can hold conversations with users in a way that is deceptively simple and easy to understand. This ability to mimic human-like conversation makes ChatGPT a more engaging and interactive tool for conversations, making users feel like they are talking to a real person rather than a robot. Notably, the recently launched multimodal GPT-4 can also accept and understand image inputs, in addition to text inputs, enabling ChatGPT to "see" things. These new features significantly expand its capability to facilitate human-like conversations.

One notable use of ChatGPT is that it can distil complex scientific theories and concepts into simple language to enhance student comprehension and retention. Fig. 1 shows an example of an explanation of Newton's first law generated by ChatGPT.



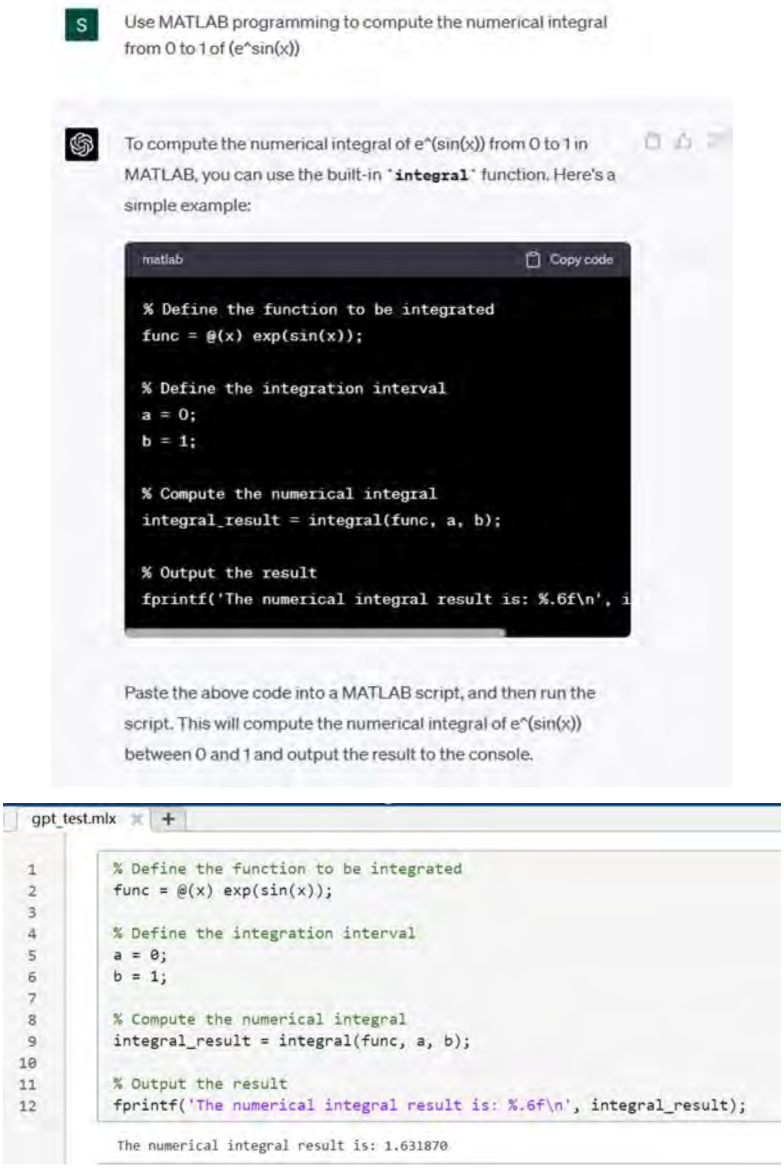
Please explain Newton's first law in simple words to a 6-year-old

Alright kiddo, imagine you're playing with a toy car. Newton's first law says that if the car is not moving, it will stay still until you push it. And once you start pushing it and let go, it will keep moving in a straight line until something like your hand or a wall stops it. So, things like to stay the way they are, either not moving or moving in a straight line, until something changes that. That's what Newton's first law tells us!

Fig. 1. Explaining Newton's first law

Providing expert solutions and guidance for complex tasks. Most AI applications including ChatGPT are designed by collecting expert knowledge from specific domains (e.g., medical diagnoses, fraud detection), which allows the machine to make decisions to solve complex problems like a human expert by extracting the knowledge stored in the knowledge base and making reasoning and inferences based on the rules and user queries. The integration of knowledge management, especially the externalization of tacit knowledge and systemic organization of knowledge, into educational systems has received growing attention and is increasingly promoted in academic research and practice in education and management (Wang & Yang, 2009).

Drawing upon the expert knowledge stored in its knowledge base, ChatGPT can generate model solutions to complex tasks (e.g., completing computer program code, solving mathematical problems, creating sample essays). Fig. 2 demonstrates how ChatGPT completed a task of solving a mathematical problem. The task was to calculate a definite integral (expressed as $\int_0^1 e^{\sin x} dx$) in numerical methods by using MATLAB programming. The output depicts the problem-solving process and result, showing ChatGPT's flawless performance in solving this problem.



Use MATLAB programming to compute the numerical integral from 0 to 1 of (e^sin(x))

To compute the numerical integral of e^(sin(x)) from 0 to 1 in MATLAB, you can use the built-in `integral` function. Here's a simple example:

```matlab
% Define the function to be integrated
func = @(x) exp(sin(x));

% Define the integration interval
a = 0;
b = 1;

% Compute the numerical integral
integral_result = integral(func, a, b);

% Output the result
fprintf('The numerical integral result is: %.6f\n', i
```

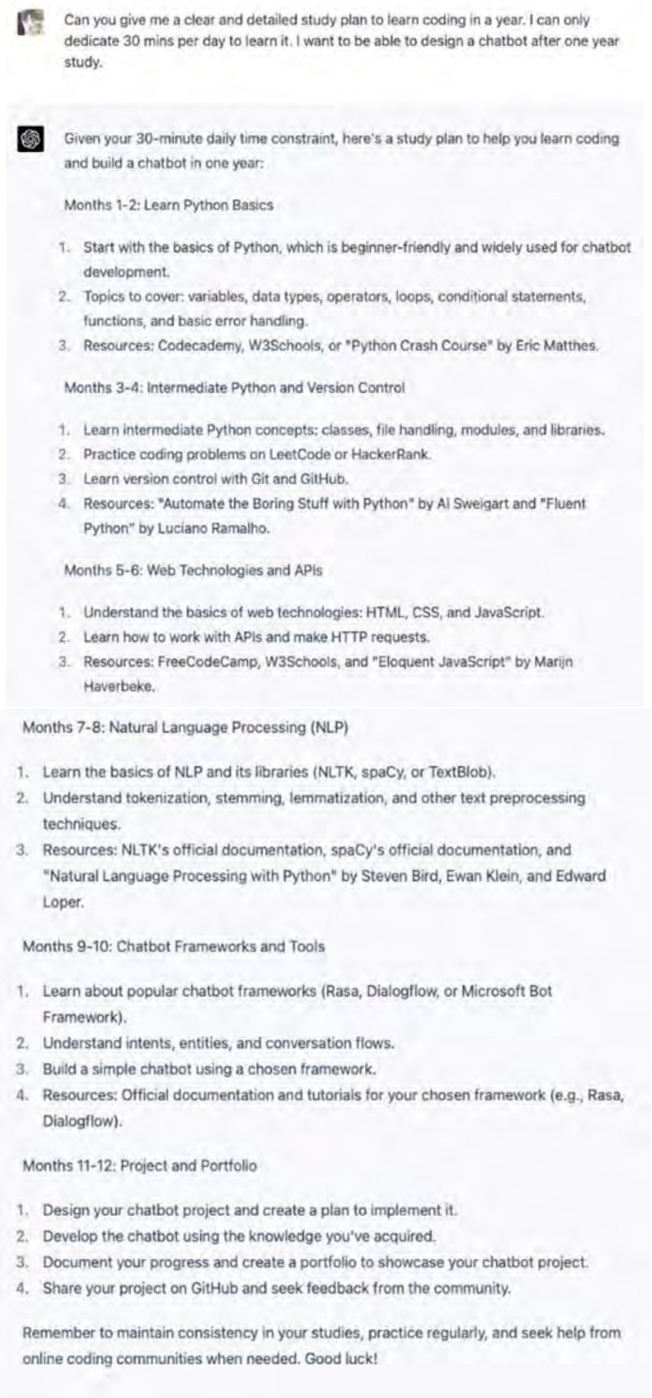
Paste the above code into a MATLAB script, and then run the script. This will compute the numerical integral of e^(sin(x)) between 0 and 1 and output the result to the console.

```matlab
% Define the function to be integrated
func = @(x) exp(sin(x));

% Define the integration interval
a = 0;
b = 1;

% Compute the numerical integral
integral_result = integral(func, a, b);

% Output the result
fprintf('The numerical integral result is: %.6f\n', integral_result);
```

```
The numerical integral result is: 1.631870
```

Fig. 2. Solving a mathematical problem

In addition to generating complete solutions, it can offer guidance or suggestions on breaking down a complex task into a series of steps, providing detailed step-by-step instructions to scaffold the task process. Fig. 3 shows an example of a study plan generated by ChatGPT for a learner who aims to learn computer coding for designing a chatbot by dedicating 30 minutes per day over the course of one year. The output exhibits ChatGPT's impressive capability to complete this task by streamlining the process of designing appropriate curricula and customising the learning process according to the learner's request.



Can you give me a clear and detailed study plan to learn coding in a year. I can only dedicate 30 mins per day to learn it. I want to be able to design a chatbot after one year study.

Given your 30-minute daily time constraint, here's a study plan to help you learn coding and build a chatbot in one year:

Months 1-2: Learn Python Basics

1. Start with the basics of Python, which is beginner-friendly and widely used for chatbot development.
2. Topics to cover: variables, data types, operators, loops, conditional statements, functions, and basic error handling.
3. Resources: Codecademy, W3Schools, or "Python Crash Course" by Eric Matthes.

Months 3-4: Intermediate Python and Version Control

1. Learn intermediate Python concepts: classes, file handling, modules, and libraries.
2. Practice coding problems on LeetCode or HackerRank.
3. Learn version control with Git and GitHub.
4. Resources: "Automate the Boring Stuff with Python" by Al Sweigart and "Fluent Python" by Luciano Ramalho.

Months 5-6: Web Technologies and APIs

1. Understand the basics of web technologies: HTML, CSS, and JavaScript.
2. Learn how to work with APIs and make HTTP requests.
3. Resources: FreeCodeCamp, W3Schools, and "Eloquent JavaScript" by Marijn Haverbeke.

Months 7-8: Natural Language Processing (NLP)

1. Learn the basics of NLP and its libraries (NLTK, spaCy, or TextBlob).
2. Understand tokenization, stemming, lemmatization, and other text preprocessing techniques.
3. Resources: NLTK's official documentation, spaCy's official documentation, and "Natural Language Processing with Python" by Steven Bird, Ewan Klein, and Edward Loper.

Months 9-10: Chatbot Frameworks and Tools

1. Learn about popular chatbot frameworks (Rasa, Dialogflow, or Microsoft Bot Framework).
2. Understand intents, entities, and conversation flows.
3. Build a simple chatbot using a chosen framework.
4. Resources: Official documentation and tutorials for your chosen framework (e.g., Rasa, Dialogflow).

Months 11-12: Project and Portfolio

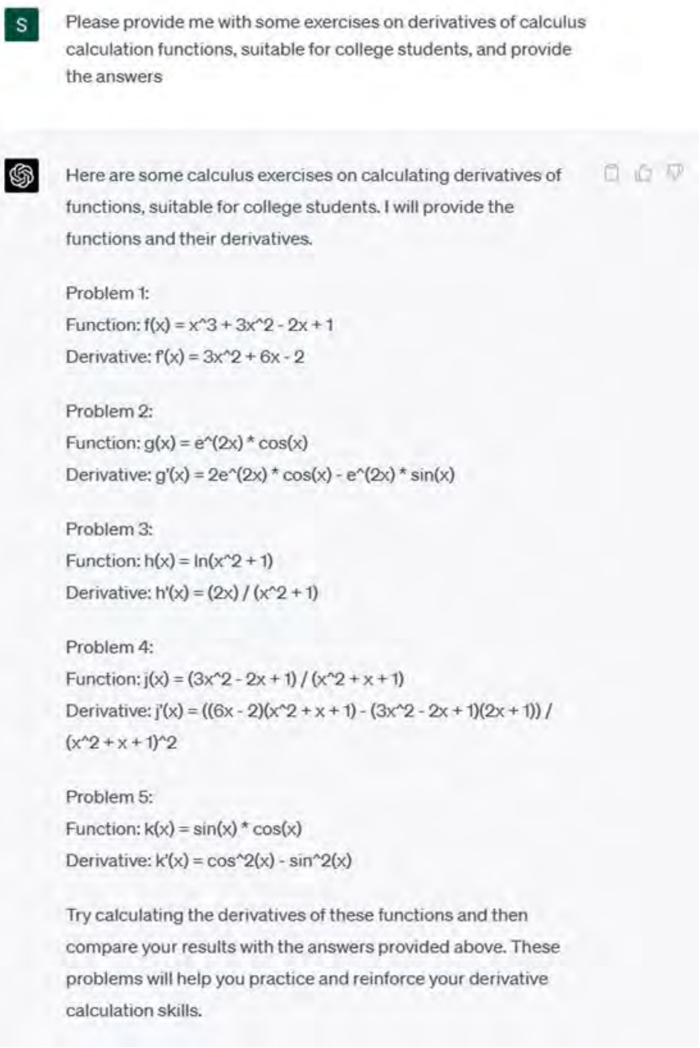
1. Design your chatbot project and create a plan to implement it.
2. Develop the chatbot using the knowledge you've acquired.
3. Document your progress and create a portfolio to showcase your chatbot project.
4. Share your project on GitHub and seek feedback from the community.

Remember to maintain consistency in your studies, practice regularly, and seek help from online coding communities when needed. Good luck!

Fig. 3. Setting up a study plan

Creating human-like writing or content. As an AI tool developed based on an advanced language model, ChatGPT has garnered substantial recognition and widespread appreciation for its capability to generate content that resembles human-generated material such as essays, stories, and poems based on user requests (Rudolph et al., 2023). Its potential to support academic writing in medical or clinical settings has been recognised in clinical practice and research contexts (Arif et al., 2023; Cascella et al., 2023).

With this function, ChatGPT can help teachers to prepare materials for teaching and learning. Fig. 4 presents a few exercise questions with reference answers on calculating derivatives, generated by ChatGPT to support the teaching and learning of calculus.



Please provide me with some exercises on derivatives of calculus calculation functions, suitable for college students, and provide the answers

Here are some calculus exercises on calculating derivatives of functions, suitable for college students. I will provide the functions and their derivatives.

Problem 1:
Function: f(x) = x^3 + 3x^2 - 2x + 1
Derivative: f'(x) = 3x^2 + 6x - 2

Problem 2:
Function: g(x) = e^(2x) * cos(x)
Derivative: g'(x) = 2e^(2x) * cos(x) - e^(2x) * sin(x)

Problem 3:
Function: h(x) = ln(x^2 + 1)
Derivative: h'(x) = (2x) / (x^2 + 1)

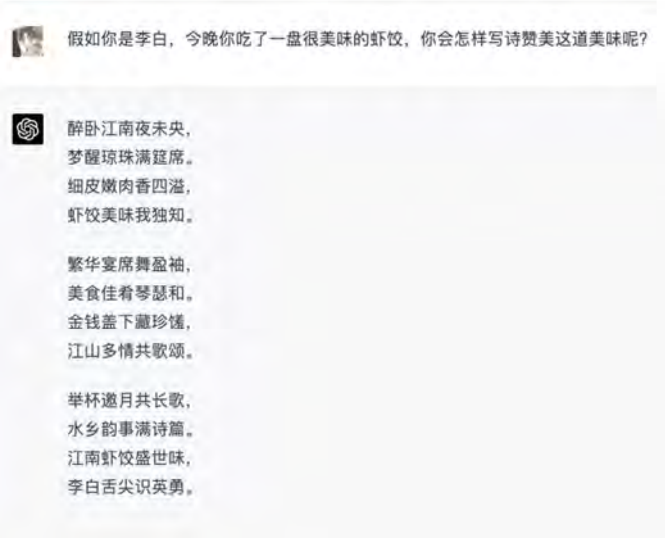
Problem 4:
Function: j(x) = (3x^2 - 2x + 1) / (x^2 + x + 1)
Derivative: j'(x) = ((6x - 2)(x^2 + x + 1) - (3x^2 - 2x + 1)(2x + 1)) / (x^2 + x + 1)^2

Problem 5:
Function: k(x) = sin(x) * cos(x)
Derivative: k'(x) = cos^2(x) - sin^2(x)

Try calculating the derivatives of these functions and then compare your results with the answers provided above. These problems will help you practice and reinforce your derivative calculation skills.

Fig. 4. Generating exercise questions with reference answers on calculating derivatives

ChatGPT's ability to compose ancient Chinese poetry is also impressive (see an example in Fig. 5), demonstrating its potential to enrich literary education by generating culturally pertinent and stylistically diverse content.



假如你是李白，今晚你吃了一盘很美味的虾饺，你会怎样写诗赞美这道美味呢?

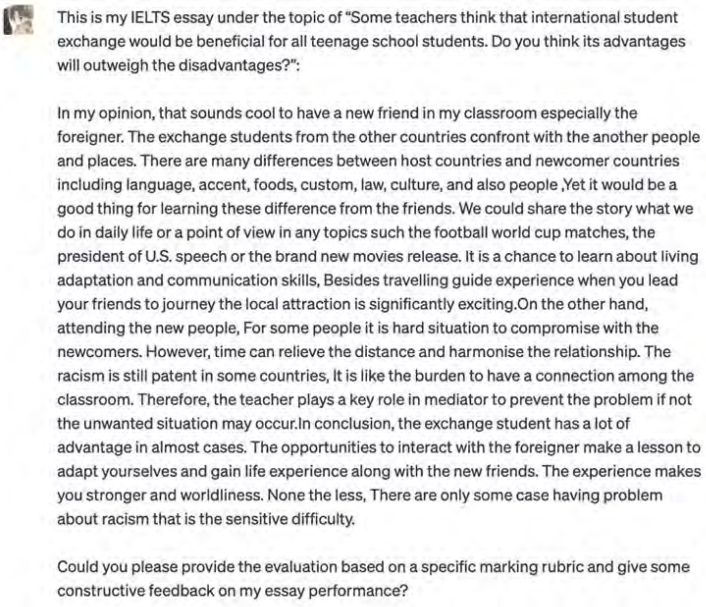
醉卧江南夜未央，
梦醒琼珠满筵席。
细皮嫩肉香四溢，
虾饺美味我独知。

繁华宴席舞盈袖，
美食佳肴琴瑟和。
金钱盖下藏珍馐，
江山多情共歌颂。

举杯邀月共长歌，
水乡韵事满诗篇。
江南虾饺盛世味，
李白舌尖识英勇。

Fig. 5. Writing ancient Chinese poetry

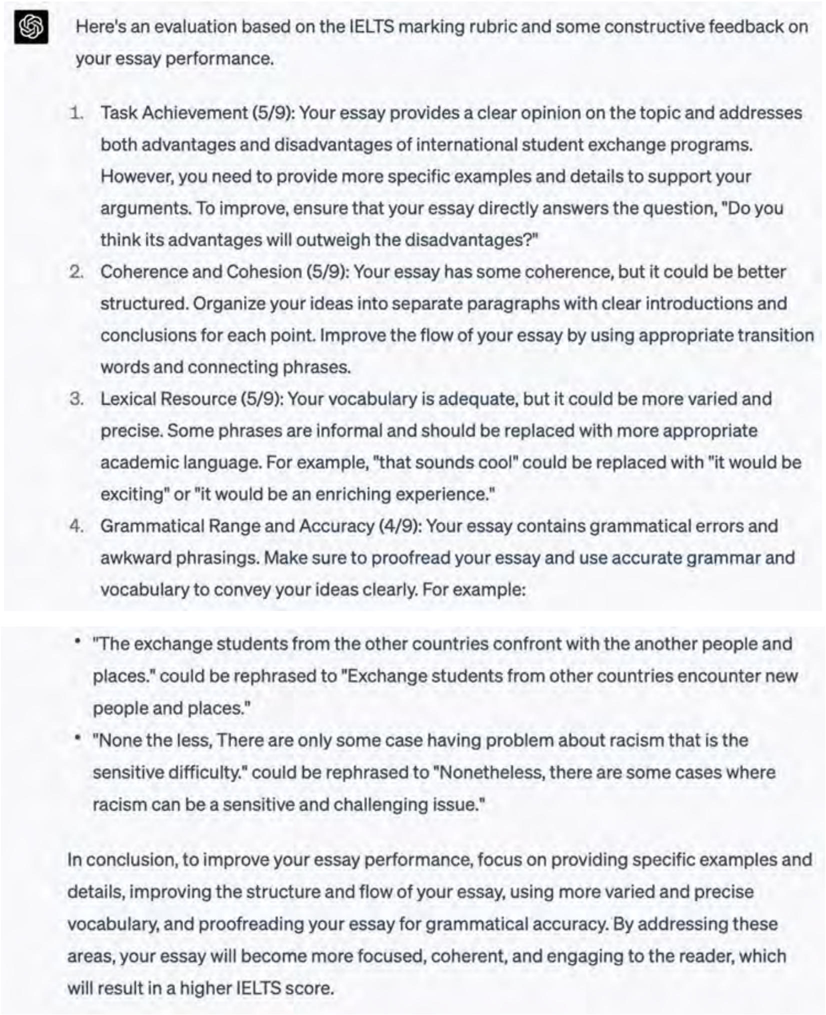
Evaluating task performance and giving feedback. Designed with expert knowledge stored in the knowledge base, ChatGPT can generate model answers or solutions to complex problem-solving tasks. Leveraging such knowledge and model answers, ChatGPT can assess students' performance reflected in their task output, assignments, or essays, especially those in text-based forms (Cotton et al., 2023). Moreover, ChatGPT can create assessment rubrics and checklists and give informative feedback. In this way, ChatGPT can assist teachers in assessing student work as well as help students to make self-assessments, with a view to tracking learning progress and addressing knowledge gaps or misconceptions. Fig. 6 shows an example of how ChatGPT evaluates the performance of an essay and gives feedback.



This is my IELTS essay under the topic of "Some teachers think that international student exchange would be beneficial for all teenage school students. Do you think its advantages will outweigh the disadvantages?":

In my opinion, that sounds cool to have a new friend in my classroom especially the foreigner. The exchange students from the other countries confront with the another people and places. There are many differences between host countries and newcomer countries including language, accent, foods, custom, law, culture, and also people ,Yet it would be a good thing for learning these difference from the friends. We could share the story what we do in daily life or a point of view in any topics such the football world cup matches, the president of U.S. speech or the brand new movies release. It is a chance to learn about living adaptation and communication skills, Besides travelling guide experience when you lead your friends to journey the local attraction is significantly exciting.On the other hand, attending the new people, For some people it is hard situation to compromise with the newcomers. However, time can relieve the distance and harmonise the relationship. The racism is still patent in some countries, It is like the burden to have a connection among the classroom. Therefore, the teacher plays a key role in mediator to prevent the problem if not the unwanted situation may occur.In conclusion, the exchange student has a lot of advantage in almost cases. The opportunities to interact with the foreigner make a lesson to adapt yourselves and gain life experience along with the new friends. The experience makes you stronger and worldliness. None the less, There are only some case having problem about racism that is the sensitive difficulty.

Could you please provide the evaluation based on a specific marking rubric and give some constructive feedback on my essay performance?



Here's an evaluation based on the IELTS marking rubric and some constructive feedback on your essay performance.

1. Task Achievement (5/9): Your essay provides a clear opinion on the topic and addresses both advantages and disadvantages of international student exchange programs. However, you need to provide more specific examples and details to support your arguments. To improve, ensure that your essay directly answers the question, "Do you think its advantages will outweigh the disadvantages?"
2. Coherence and Cohesion (5/9): Your essay has some coherence, but it could be better structured. Organize your ideas into separate paragraphs with clear introductions and conclusions for each point. Improve the flow of your essay by using appropriate transition words and connecting phrases.
3. Lexical Resource (5/9): Your vocabulary is adequate, but it could be more varied and precise. Some phrases are informal and should be replaced with more appropriate academic language. For example, "that sounds cool" could be replaced with "it would be exciting" or "it would be an enriching experience."
4. Grammatical Range and Accuracy (4/9): Your essay contains grammatical errors and awkward phrasings. Make sure to proofread your essay and use accurate grammar and vocabulary to convey your ideas clearly. For example:

- "The exchange students from the other countries confront with the another people and places." could be rephrased to "Exchange students from other countries encounter new people and places."
- "None the less, There are only some case having problem about racism that is the sensitive difficulty." could be rephrased to "Nonetheless, there are some cases where racism can be a sensitive and challenging issue."

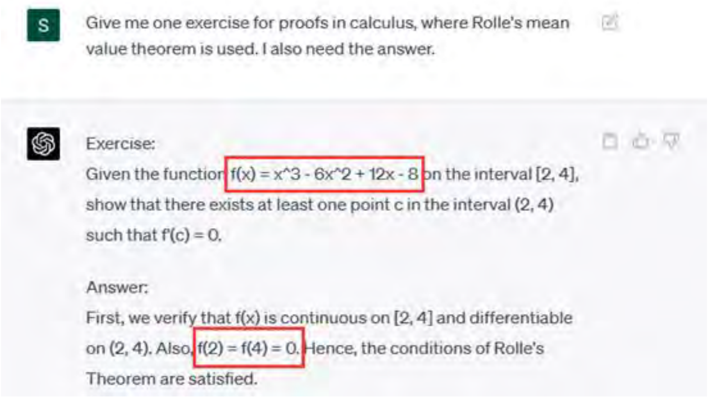
In conclusion, to improve your essay performance, focus on providing specific examples and details, improving the structure and flow of your essay, using more varied and precise vocabulary, and proofreading your essay for grammatical accuracy. By addressing these areas, your essay will become more focused, coherent, and engaging to the reader, which will result in a higher IELTS score.

Fig. 6. Evaluating an essay

2.2. Weaknesses of ChatGPT

Despite being a disruptive AI application, ChatGPT has limitations that may present challenges and risks to its potential use in teaching and learning practice.

Inclusion of inaccurate, fabricated, and biased information in its output. As highlighted in several scholarly studies (e.g., Abdullah et al., 2022; Mhlanga, 2023), the output of generative AI is contingent upon the model's quality, its knowledge base, and the database it has been trained on to generate output. Although ChatGPT has access to massive amounts of information, its knowledge base is not exhaustive. Moreover, ChatGPT's training data is sourced from various repositories that may contain incomplete or biased information and even inaccuracies or errors, which can occasionally be reflected in its responses. Fig. 7 shows an error generated by ChatGPT in a calculus proof. The answer given by ChatGPT showed "$f(2) = f(4) = 0$", but in fact $f(4) = 8$. Consequently, one limitation of ChatGPT is that it may not consistently provide accurate or relevant responses and might occasionally produce fabricated and biased information (Brown et al., 2020; Mbakwe et al., 2023). The problem can be more serious when ChatGPT increases the risk of misinformation spreading in scientific publications (Liebrenz et al., 2023).



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Give me one exercise for proofs in calculus, where Rolle's mean value theorem is used. I also need the answer.

Exercise:
Given the function f(x) = x^3 - 6x^2 + 12x - 8 on the interval [2, 4], show that there exists at least one point c in the interval (2, 4) such that f'(c) = 0.

Answer:
First, we verify that f(x) is continuous on [2, 4] and differentiable on (2, 4). Also, f(2) = f(4) = 0. Hence, the conditions of Rolle's Theorem are satisfied.

Fig. 7. An error generated in a calculus proof

More concerning, ChatGPT lacks self-awareness, and it sometimes presents misinformation with high confidence. Although it can recognise and rectify its errors when prompted by the user, the potential for generating inaccurate or irrelevant responses remains a significant challenge in education. If students rely on ChatGPT for assistance, inaccurate or irrelevant responses could result in confusion and misunderstandings.

Lack of critical thinking and in-depth understanding in its output. As a language model, ChatGPT is trained to generate text based on language patterns extracted from existing text sources. While it can produce output resembling known content, it lacks the capacity to fully comprehend the concepts underlying the words. In other words, although ChatGPT possesses the capability to search for and summarize relevant information, it has limited capacity to develop an in-depth understanding of the content compared to humans who possess contextual knowledge and subjective perceptions (Farrokhnia et al., 2023). As a consequence, the output (e.g., responses, essays) generated by ChatGPT is sometimes lacking depth and potentially off-topic (Anderson et al., 2023; Arif et al., 2023), especially when it relates to theoretical concepts (Sinha et al., 2023).

ChatGPT's limited capability to deeply understand the content underlying the words may lead to its lack of higher-order thinking skills, such as critical and analytical thinking skills (Rudolph et al., 2023). For example, ChatGPT has limited capability to generate higher-level, critical-thinking-type questions that require a deeper comprehension of the subject matter (Sun & Hoelscher, 2023). Students who excessively rely on responses generated by AI might become less adept at critical thinking.

2.3. Opportunities for the use of ChatGPT

In this section, we discuss the main opportunities, i.e., the external factors that may potentially benefit the use of ChatGPT in education.

Growing demand for online learning. The demand for online learning has experienced remarkable growth in recent years, driven by a confluence of factors such as burgeoning educational needs, the necessity for lifelong learning in response to an evolving job market, the imperative to bridge the skills gap in non-traditional educational environments, and an emphasis on educational equality, accessibility, and inclusivity. These factors present a unique opportunity for ChatGPT to capitalise on the expanding online learning landscape, as its advanced capabilities can be leveraged to address diverse educational needs and challenges.

Increased need for personalized learning support. In education, there is a growing demand for personalized teaching and learning to address individual learning needs, for example by offering flexible learning environments, creating personalized learning content, and providing individualized learning support. While this is difficult to achieve in conventional education systems, advances in technology (e.g., intelligent tutoring systems, generative AI, chatbots) have shown great potential to address this demand, which has been expanding in educational institutions as well as workplace settings.

While the increasing demand for online learning and personalized learning support presents opportunities for the use of ChatGPT in education, the strong accessibility, scalability, and affordability of ChatGPT greatly expand the availability of quality education and meet the needs of numerous learners simultaneously, especially in situations where formal education is either limited or unaffordable. However, it is worth noting that lower-income individuals may not be able to afford the ChatGPT Plus subscription, potentially creating unequal access. Nonetheless, in most cases, compared to other technologies like traditional intelligent tutoring systems, ChatGPT is not bound by prerequisites such as specialized hardware or software and other restrictions, making it a more attractive alternative for enhancing the quality of education and expanding access to high-quality educational experiences.

2.4. Threats to the use of ChatGPT

This section presents the main threats, i.e., the external factors that could potentially hinder the integration of ChatGPT in education.

AI-assisted cheating. A major threat is the concern surrounding AI-assisted cheating (Lim et al., 2023). Some educators are afraid that students will outsource their work to ChatGPT because of its ability to rapidly generate acceptable texts, making it difficult to detect plagiarism cases (Lo, 2023; Mhlanga, 2023). It is noted that ChatGPT has shown impressive performance in generating moderately accurate responses to pass university examinations in the fields of law (Choi et al., 2023) and medicine (Gilson et al., 2023). With such performance, ChatGPT may pose a threat to academic integrity and bring negative effects on traditional assessment practice if it is used in a dishonest manner.

Data privacy and security. The introduction of ChatGPT in education and academic settings has raised concerns about privacy and data security. As ChatGPT collects and stores user information and experience data, there is a risk that the collected data could be accessed or misused by third parties. In addition, the potential for security breaches or hacking incidents could compromise the integrity and confidentiality of student data.

Resistance from the realm of education. In view of the potential risk and challenges mentioned above, many governments and educational institutions have prohibited generative AI tools (Lim et al., 2023). Earlier this January, the New York City Department of Education blocked the chatbot from school networks and devices across the district, citing concerns about plagiarism and inaccurate information (Elsen-Rooney, 2023).

Several school districts, including the Seattle Public Schools and Los Angeles Unified School District, have banned the bot, citing fears of plagiarism and false information (Nolan, 2023). In the Higher education sectors, universities like Sciences Po in France have also taken steps to stop the use of ChatGPT for cheating (Nolan, 2023).

Socio-cultural and technological issues. Students from different socio-cultural backgrounds may have varying levels of knowledge about ChatGPT and may have different expectations and preferences about its use. Similarly, teacher attitudes towards new technology can vary widely, with some educators viewing it as a valuable tool for enhancing learning, while others being sceptical or even resistant to its use. Another issue is related to the digital divide. For example, not all students have the equipment and skills required for using ChatGPT.

2.5. Overview of the SWOT analysis

Based on the above SWOT analysis, we present an overview of the main strengths and weaknesses of ChatGPT as well as the external factors that may bring opportunities and threats to its use in education (see Fig. 8).

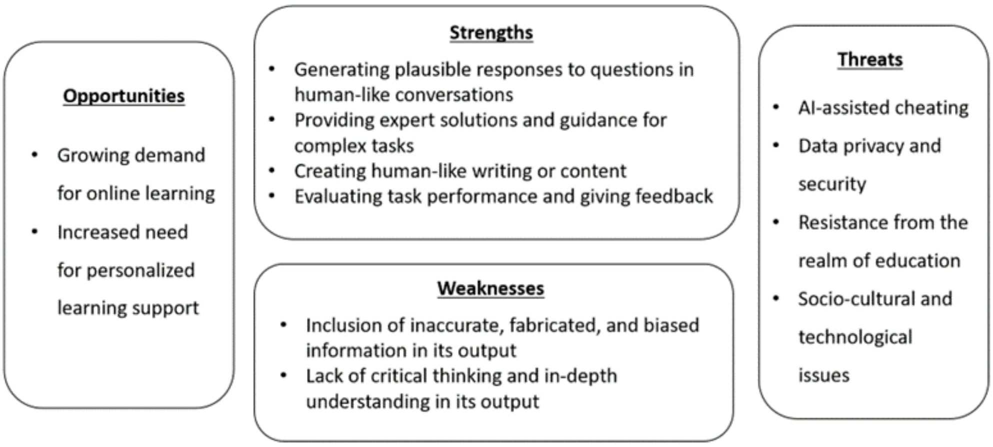
Opportunities
Growing demand for online learning
Increased need for personalized learning support
Strengths
Generating plausible responses to questions in human-like conversations
Providing expert solutions and guidance for complex tasks
Creating human-like writing or content
Evaluating task performance and giving feedback
Weaknesses
Inclusion of inaccurate, fabricated, and biased information in its output
Lack of critical thinking and in-depth understanding in its output
Threats
AI-assisted cheating
Data privacy and security
Resistance from the realm of education
Socio-cultural and technological issues

Fig. 8. Overview of the SWOT analysis of ChatGPT

3. How to harness the potential of ChatGPT in education?

Before we propose the strategies for harnessing the potential of ChatGPT in education, we first outline the framework of how people learn. This framework consists of four key elements: Content (C), Others (O), Self (S), and Tasks (T), collectively referred to as the COST model (Wang, 2018). As shown in Fig. 9, the COST model delineates how people learn by interacting with the four key elements, where technology plays an increasingly important role in these interactions.

- Learning by interaction with learning content (C), such as learning materials.
- Learning by interaction with others (O), i.e., other people such as teachers, peers, parents, and so on.

- Learning by interaction with self (S), for example self-reflection, and self-regulation.
- Learning by interaction with problem-solving tasks (T), i.e., applying knowledge to practice to consolidate and update knowledge.

To ensure effective interaction with the four key elements, learners need to engage in higher-order thinking during the learning process (Wang & Wegerif, 2019). Fig. 10 presents an overview of the strategies for integrating ChatGPT in education based on the COST model and the SWOT analysis of ChatGPT.

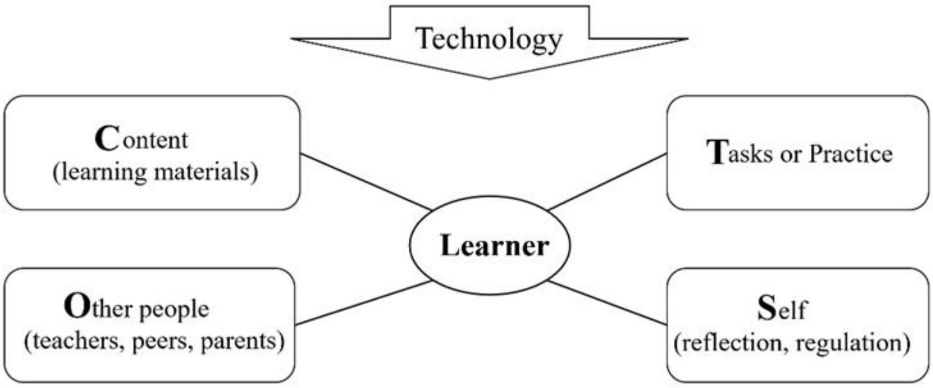
Technology
Content
(learning materials)
Tasks or Practice
Learner
Other people
(teachers, peers, parents)
Self
(reflection, regulation)

Fig. 9. COST model

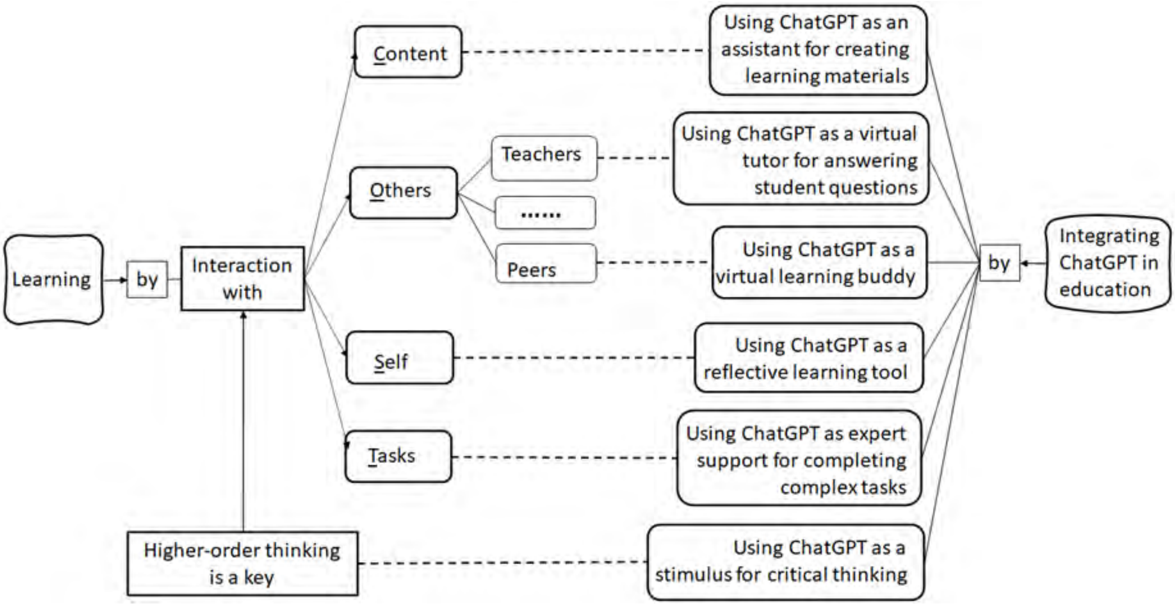
Learning
by
Interaction with
Content
Others
Teachers
......
Peers
Self
Tasks
Higher-order thinking is a key
Using ChatGPT as an assistant for creating learning materials
Using ChatGPT as a virtual tutor for answering student questions
Using ChatGPT as a virtual learning buddy
Using ChatGPT as a reflective learning tool
Using ChatGPT as expert support for completing complex tasks
Using ChatGPT as a stimulus for critical thinking
by
Integrating ChatGPT in education

Fig. 10. Strategies for integrating ChatGPT in education

3.1. Using ChatGPT as a virtual tutor for answering student questions

Teacher-student interaction is a vital part of the learning process. Students require constant support from teachers, such as delivering learning content and providing guidance and responses to various questions. ChatGPT has shown superior performance in understanding complex questions and generating plausible answers in human-like text. It can hold human-like conversations with learners to provide user-friendly responses to questions as well as follow-up questions and facilitate discussions in a way that is deceptively simple and easy to understand.

In this way, ChatGPT can be used as a virtual tutor to provide instant and personalized support to learners. While self-regulated learning has been widely promoted in educational settings, the provision of personalized support to sustain self-regulated learning is crucial but inadequately accomplished. In such contexts, ChatGPT can act as a virtual tutor, expanding the availability of personalized learning support to meet the needs of numerous learners simultaneously, especially in situations where formal education is either limited or unaffordable.

However, it should be noted that sometimes the responses from ChatGPT might include incorrect, fabricated, or biased information. Learners need to develop the ability to verify the output and discern between genuine and unreliable sources of information. ChatGPT is not intended to replace in-person instruction from qualified teachers and tutors. Instead, it can be seen as a tool that can supplement classroom instruction and support student learning.

3.2. Using ChatGPT as an assistant for creating learning materials

The interaction between students and learning content (e.g., searching for and reading learning materials) is a fundamental part of the learning process. ChatGPT can search for relevant information and summarize it in human-like text to respond to user questions (Cascella et al., 2023). Compared to traditional search engines, ChatGPT is more capable of summarizing relevant content for efficient learning rather than just offering a list of sources. In this way, ChatGPT can play the role of assistant that helps teachers to create additional learning materials.

Different from conventional course materials, the learning content generated by ChatGPT has a clear focus on student questions or confusions together with responses to these questions or confusions. With a focus on addressing student questions, such materials may help students to overcome difficulties in their learning process.

In language education, ChatGPT can also be used to generate coherent writing, translation, and interactive dialogues to support language learning (Topsakal & Topsakal, 2022). Moreover, ChatGPT can also be used to support teachers to generate quizzes or other assessment materials such as open-ended questions, multiple-choice questions, and scenarios for assessment of student performance (Farrokhnia et al., 2023; Lo, 2023).

Considering that responses from ChatGPT might include incorrect, fabricated or biased information, teachers need to carefully check AI-generated content to ensure its correctness and appropriateness before using it in teaching and learning practice.

3.3. Using ChatGPT as expert support for completing complex tasks

Learning by working with problem-solving tasks has been widely promoted in educational research and practice. It enables learners to develop capabilities to apply knowledge to practice to consolidate and update knowledge. Nevertheless, many students encounter difficulties in completing complex tasks. While it is challenging for teachers to provide personalized support to learners during the task, technology has played an increasingly important role to support learning with complex tasks (Wang et al., 2017).

ChatGPT possessed the capability to generate solutions and guidance for completing complex tasks (e.g., offering sample essays, completing computer program code, proposing project plans) based on the expert knowledge stored in its knowledge base. With this capability, ChatGPT can act as an expert that helps learners to complete complex tasks in specific domains. It can provide sample solutions or demonstrate desired behaviours or skills for learners to observe and imitate, in addition to providing detailed step-by-step instructions to scaffold the task process. For example, in an essay-writing task, ChatGPT can provide samples of well-structured essays, allowing students to observe how experts organise their thoughts and develop arguments (Topsakal & Topsakal, 2022). In programming learning, it can provide superior support for writing program code (e.g., code completion and correction, code suggestion, syntax error fixing, code optimization) along with detailed instructions and explanations, which even human teachers may not consistently offer (Biswas, 2023).

3.4. Using ChatGPT as a virtual learning buddy

Learning by interaction and collaboration with peers has been widely promoted in educational research and practice. Learners are encouraged to interact and work with peers to engage in collaborative learning and problem-solving tasks. By generating human-like responses to users, ChatGPT can play the role of a learning buddy to enrich collaborative learning activities. It can facilitate discussions and interactive learning among peers by providing alternative perspectives and ideas to supplement peer collaboration in group work. In classroom settings, teachers can also use ChatGPT to engage students in conversations, collaboration, and even debates with ChatGPT.

Meanwhile, it should be noted that emotional considerations are a crucial aspect of human communication, which enable individuals to understand and respond appropriately to the nuances and complexities of interpersonal interactions. However, ChatGPT lacks emotional intelligence, which may hinder its ability to effectively interact ad engage with humans. Its limitations in this area could also potentially lead to misunderstandings or misinterpretations of human language, resulting in less-than-optimal communication.

3.5. Using ChatGPT as a reflective learning tool

During the learning process, a learner needs to interact with him/herself for self-reflection, self-assessment, and self-regulation. Reflective learning is an important form of education, in which students review and reflect upon their learning experiences to improve future performance, enabling students to take ownership of their learning.

Deployed with expert knowledge for generating solutions to complex tasks, ChatGPT can be programmed with algorithms to assess students' responses to tasks, assignments and essays and give informative feedback on student performance. In this way, ChatGPT can be used as a reflective learning tool, helping learners to reflect on his/her performance and figure out knowledge gaps or misconceptions, with a view to improving the learning process and associated outcomes.

3.6. Using ChatGPT as a stimulus for critical thinking

As mentioned, ChatGPT has weaknesses in terms of (a) the inclusion of inaccurate, fabricated, and biased output in its output, and (b) the lack of in-depth understanding and critical thinking in its output. Students who excessively rely on AI to copy and paste answers may neglect inaccurate or biased responses from AI and hinder the development of critical thinking skills and in-depth understanding of learning materials. To this end, educators should carefully guide and monitor students' use of ChatGPT and consistently emphasize the importance of critical thinking and in-depth understanding.

On the other hand, ChatGPT has shown the capability to stimulate critical thinking by facilitating follow-up questions in a sustained dialog that develops and expands answers and responds to challenging questions. As an intelligent conversational agent, ChatGPT can act as a stimulus of critical thinking, for example by helping students to engage in critical thinking through debates with chatbots. Activities that foster the development of critical thinking skills with the use of ChatGPT, such as analysis and evaluation of the output provided by ChatGPT, can be incorporated into teaching and learning practice.

3.7. Measures to ensure the responsible and ethical use of AI

The integration of ChatGPT in educational practice requires respect for privacy, fairness, transparency, and non-discrimination to ensure the responsible and ethical use of AI (Mhlanga, 2023). To do so, relevant policies and administrative measures can be set up with a focus on the following issues.

Ensuring data privacy and security. Protecting the privacy of user data is a primary priority in adopting ChatGPT and other AI applications. Because ChatGPT is trained on enormous volumes of data, it is essential to ensure that the personal data of students is safeguarded and not put to inappropriate use. Before using ChatGPT in the classroom, educators should inform students about how their data is gathered and used and acquire their consent. In addition, students should be aware of the security measures that are in place to protect their data. It is imperative to maintain the confidentiality of all individuals participating in the educational process.

Reducing the risk of AI-assisted cheating in assessment. Educations need to refine the design of assessment tasks to avoid AI-assisted cheating. Multiple forms of assessment such as oral presentations, hands-on projects, laboratory experiments, and field trips can be taken into account.

Providing necessary training and education to teachers and students. When AI continues to progress and becomes more pervasive in education, it is vital to help educators and students to be equipped with necessary knowledge and skills to successfully traverse the technological landscape. Educators and students need to understand how ChatGPT and other similar AI tools work, their capabilities and limitations, and how to harness the potential of AI in teaching and learning practice. They need to be trained on how the tool can be used properly and effectively, for example how to give explicit instead of vague or ambiguous input to the machine to obtain comprehensive and detailed answers from AI.

Meanwhile, students and teachers should be introduced to the risks of incorrect, fabricated, and biased information included in AI-generated responses, the negative effects of such risks, and the importance of developing critical thinking skills to minimize the risks. Teachers can be trained on how to use AI properly to support teaching and assessment activities as well. Considering that ChatGPT is likely to become increasingly prevalent in the workplace, it is imperative that students are taught how to use it proficiently and acquire the skills they need to thrive in a rapidly changing technological landscape.

4. Conclusions

Despite its widespread application in various domains, the introduction of ChatGPT into education has sparked a lot of discussions and debates. In this paper, we present a thorough SWOT analysis of ChatGPT, based on which we propose a set of strategies for the integration of ChatGPT in teaching and learning practice to harness its potential in education.

As a ground-breaking AI application, ChatGPT offers multiple strengths with its capabilities to generate plausible responses to questions in human-like conversations, provide expert solutions and guidance for complex tasks, create human-like writing or content, and evaluate task performance and give feedback. Meanwhile, ChatGPT has weaknesses, such as the inclusion of inaccurate, fabricated, and biased information in its output, and the lack of critical thinking and in-depth understanding in its output. ChatGPT's capabilities and limitations, as well as external factors (e.g., growing demand for personalized learning support, irresponsible and unethical use of AI), have presented both opportunities and challenges to the potential use of ChatGPT in education.

Based on the SWOT analysis and the COST model for human learning, we propose a set of strategies for harnessing the potential of ChatGPT in education.

- Using ChatGPT as a virtual tutor for answering student questions
- Using ChatGPT as an assistant for creating learning materials
- Using ChatGPT as expert support for completing complex tasks
- Using ChatGPT as a virtual learning buddy
- Using ChatGPT as a reflective learning tool
- Using ChatGPT as a stimulus for critical thinking

In addition to the above strategies, relevant policies and administrative measures should be set up to ensure data privacy and security, mitigate the risk of AI-assisted cheating in assessment, and provide necessary training and education to teachers and students to ensure the responsible and ethical use of ChatGPT in educational practice. Given the rapid evolution of ChatGPT as a technology, educators and policymakers should remain vigilant and responsive to new developments and consistently reassess how the potential of ChatGPT and other related AI applications can be harnessed in an effective and appropriate manner by maximizing its benefits and minimizing negative consequences.

Furthermore, the superior performance of generative AI applications has demonstrated the value of tacit knowledge extracted from human experts and datasets and the potential of integrating such knowledge into educational practice. While AI applications deployed with such knowledge can be used to support teaching and learning in schools and workplace settings, it is important to make such tacit knowledge (e.g., problem-solving strategies, decision making rules, methods for coherent writing) visible and accessible to learners for sustainable learning and development. Besides, considering ChatGPT's limited capabilities to facilitate in-depth understanding and critical thinking, more efforts are needed to promote student development of higher-order thinking skills.

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ORCID

Chenjia Zhu https://orcid.org/0009-0002-1503-2382

Meng Sun https://orcid.org/0000-0002-2914-8565

Jiuting Luo https://orcid.org/0000-0003-4700-1927

Tianyi Li https://orcid.org/0000-0001-5880-4851

Minhong Wang https://orcid.org/0000-0002-1084-6814

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