

Augmenting Critical Thinking Skills in Programming Education through Leveraging Chat GPT: Analysis of its Opportunities and Consequences

Dr. Abdullah Konak, Pennsylvania State University, Berks Campus

Dr. Abdullah Konak is a Distinguished Professor of Information Sciences and Technology at the Pennsylvania State University, Berks. Dr. Konak also teaches graduate courses in the Master of Science in Cybersecurity Analytics and Operations program at the College of Information Sciences and Technology, Penn State World Campus. Dr. Konak's primary research interest focuses on modeling, analyzing, and optimizing complex systems using computational intelligence combined with probability, statistics, data sciences, and operations research. His research also involves active learning, entrepreneurship education, and the innovation mindset. Dr. Konak's published numerous academic papers on a broad range of topics, including network design, system reliability, sustainability, cybersecurity, facilities design, green logistics, production management, and predictive analytics. He has been a principal investigator in sponsored projects from the National Science Foundation, the National Security Agency, the U.S. Department of Labor, and Venture Well.

Mr. Christian Jay St. Francis Clarke, Penn State University

Christian Clarke is a current student at Penn State University, where he is diligently pursuing his Bachelor's degree in Information Sciences and Technology (IST). Originally hailing from the vibrant island of Jamaica, Christian commenced his academic journey at the prestigious University of The West Indies, where he successfully completed his initial bachelor's degree in Business Management, supplemented by a minor in psychology.

Motivated by a lifelong fascination with technology, Christian has made a deliberate choice to channel his academic endeavors into the dynamic field of Artificial Intelligence during his tenure at Penn State. His ultimate aim is to become a driving force in the ongoing research and development of Artificial Intelligence within the ever-evolving landscape of computer science.

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Christian Jay. St. Francis Clarke

Information Sciences and Technology

Penn State Berks

Abdullah Konak

Penn State Berks

Division of Engineering, Business, and Computing

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Abstract

This literature review embarks on an exploratory journey into the realm of employing Chat GPT to augment critical thinking skills within the context of programming classes. As modern education continues its digital transformation, integrating AI-driven conversational agents, such as Chat GPT, stands out as a promising pedagogical avenue.

The review begins by dissecting the learning experience phases where Chat GPT exhibits its utility. Within the preliminary programming coursework phases, Chat GPT is invaluable as a knowledge repository and interactive tool for novice learners. It helps clarify programming concepts, troubleshoot code, and encourage a nuanced understanding of algorithms. In advanced phases, when students confront complex coding challenges, Chat GPT serves as a collaborative problem-solving partner, fostering iterative exploration and promoting critical Thinking.

However, the integration of Chat GPT is not without its risks. The literature underscores the importance of vigilance during the assessment phase. Over Reliance on Chat GPT for problem-solving may inadvertently hinder students' independent critical thinking development. Moreover, academic integrity and plagiarism issues must be vigilantly addressed to ensure the authenticity of students' work.

Furthermore, the review unearths the critical notion that Chat GPT, while offering immediate support, should not replace the role of human educators. A balanced approach, where Chat GPT serves as a supplementary resource rather than a substitute, emerges as the best practice.

In conclusion, Chat GPT presents a dynamic opportunity to enhance critical thinking skills in programming classes across various learning phases. Its utility, when strategically integrated, fosters an enriched educational experience. However, educators must be cautious to strike a balance and mitigate the potential pitfalls, ensuring that the development of students' autonomous critical thinking skills remains at the forefront of programming education. This literature review paves the way for a more nuanced understanding of the symbiotic relationship between AI-driven tools like Chat GPT and the cultivation of critical thinking prowess in the domain of programming.

Introduction

Integrating artificial intelligence (AI) technologies in our daily lives has opened new avenues for exploring the relationship between human cognition and machine intelligence. As of the present moment, Chat GPT boasts a user base exceeding 100 million individuals, attracting an impressive average of 1 billion website visitors each month [1]. Such astounding data speaks to the volume of which reliance is being formed on AI. The intersection between critical thinking and Chat GPT provides an opportunity to use Advanced AI as a modern-day catalyst to drive the reasoning skills students require to solve problems in their computer classes.

ChatGPT is built on deep learning algorithms that analyze a corpus of text data. The model is trained on vast amounts of text data, enabling it to capture human language patterns, nuances, and complexities. The training corpus includes various sources, such as books, articles, reviews, online conversations, and human-generated data, allowing the model to engage in non-trivial dialogues and provide accurate information on diverse topics [2].

Within the field of computer sciences, we have seen that many students have integrated rapidly into Chat GPT to assist in writing programming code. This has now forced the academic community to assess how such AI systems will impact students and, by extension, how as educator's aspects of their critical thinking skills are being impacted by the availability of such a powerful tool. Students can engage with the AI to seek information, solve problems, and engage in idea creation. The ability to prompt students to think critically about the validity of the information given and evaluate different perspectives allows them to revise their queries. ChatGPT has exhibited top performances in many application domains, such as coherent content, essay generation and programming code [3]. Critical thinking often depends on engaging in Socratic dialogue, which encourages students to stimulate reasoning skills through open-ended questioning. Furthermore, it serves as a Socratic Dialogue Partner, encouraging students to articulate their thoughts, consider different viewpoints and refine their arguments. The ability of the AI further assists students in personalizing complex learning to each student's strengths.

While the AI revolution brings undeniable benefits to the educational landscape, instructors express significant concerns. They worry not only about the potential suppression of students' critical thinking skills but also about the risk that students might rush through the foundational coding concepts crucial for becoming effective professionals in the field.

This literature review seeks to provide insight into the landscape of critical Thinking in the context of ChatGPT, highlighting the unique opportunities and challenges this partnership presents in the context of computer science classes. This paper employs the SWOT analysis strategy to deconstruct the various aspects of Chat GPT's interaction with computer students, with a particular focus on its impact on their critical thinking skills. The SWOT analysis is broken down into Strengths, Weaknesses, Opportunities and Threats and was chosen as an effective pedagogy due to its ability to assess internal factors in a balanced and clear approach. Table 1 summarizes the results of the SWOT analysis, and the following sections introduce each component of the analysis.

Table 1. SWOT Analysis of the use of Chat-GPT in computer sciences classes through the lens of critical thinking.

<p><u>STRENGTHS</u></p> <ul style="list-style-type: none"> -Extensive knowledge base -Simplifies complex coding -Personalizes the learning pace to each student's unique input -Acts as a Socratic Dialogue Partner for solving complex programs 	<p><u>WEAKNESSES</u></p> <ul style="list-style-type: none"> -Overreliance stifles Critical Thinking skills -Operates on training data which encompasses bias -Does not add context nuanced discussions -Doesn't create diverse perspectives in solutions
<p><u>OPPORTUNITIES</u></p> <ul style="list-style-type: none"> -Personalization of learning styles empower students with teaching challenges -Fixes coding issues in real-time -Stimulates critical thinking by encouraging analysis of programming code -User friendly accessibility -Large database introduces wide array of problem-solving strategies and coding methodologies 	<p><u>THREATS</u></p> <ul style="list-style-type: none"> -Overreliance discourages learning and stifling critical thinking skills -Responses are crafted by training data which include inaccuracies and biases -Stifles creativity; discouraging students from venturing into innovative programming solutions

Strengths

Computer science classes often require students to analyze complex problems and devise innovative solutions. Critical thinking becomes a fundamental skill in this discipline and is essential for students to create programming solutions that make the code they write effective.

Chat GPT lends itself to being a significant strength as it provides instant access to a repository of knowledge that students can break down into smaller parts. The ability of the AI to provide quick explanations, examples, and references can empower students to explore topics in greater depths, which enhances their analytical abilities.

Conceptual understanding becomes a key component in students being able to clearly identify the key components needed to simplify complex programming solutions. A clear concept is a basic requirement for improved programming performance. ChatGPT can provide explanations and examples of various programming concepts (e.g., data structures, algorithms, languages, and programming language syntax) in a concise, simple, and understandable manner [3].

The vault of knowledge that Chat GPT offers gives students instant access to the questions they have on specific concepts. The AI provides quick explanations, examples and references when challenging problems occur in the code construct. This gives students access to personalized learning with tailored explanations due to Chat GPTs ability to adapt to each student's learning pace and preferences. This promotes a deeper understanding because they are now able to engage with the material at a level that suits them, which encourages students to think critically

about the subject matter. ChatGPT can help optimize codes by suggesting ways to reduce memory usage and time complexity. Moreover, the explanations provided by ChatGPT based on code reviews are valuable and help programmers better understand the problem and error in the code [3].

Such explanations can be further broken down to give students access to diverse problem-solving approaches that use comparative analysis and present students with the ability to think critically about which approach is most appropriate for the given problem. This is accomplished by drawing on expert information stored in its knowledge base. ChatGPT can generate model solutions to complex tasks from this knowledge base and 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 [4].

Chat-GPT can also create real-world examples and case studies related to computer science concepts. This practical context helps students connect theory to real-life scenarios, fostering critical thinking by encouraging them to analyze how theoretical knowledge can be applied to solve real problems. This also leads to facilitating collaborative learning by enabling group discussions and brainstorming sessions from the different scenarios being generated. This collaborative approach not only enhances critical thinking but also encourages effective communication and teamwork skills.

The data shows that Chat GPT has become a Socratic Dialogue Partner within the context of computing due to its problem-solving capacity. It has become a high-level conversational agent by engaging students in probing discussions to facilitate deeper critical thinking skills. Engaging in such dialectical exchanges develops logical reasoning, algorithm thinking and a capacity for innovation with technical expertise to support its conclusion.

A Socratic Dialogue partner is designed to engage learning through thought-provoking discussions. By leveraging the principles of the Socratic method, it fosters critical thinking by encouraging the exploration of concepts through open-ended questions and challenging preconceived notions. Such a dynamic exchange allows brainstorming solutions and adapts to the individual's learning style by stimulating deeper reasoning. Such a tool enables computer students who use Chat GPT to refine their coding skills, develop a strong grasp of complex computational concepts and develop a consistent algorithmic approach to coding.

Chat-GPT brings many strengths to computer classes, which can significantly enhance students' critical thinking skills if used correctly. Its ability to provide instant information, offer personalized learning experiences, expose students to diverse problem-solving approaches, and promote real-world applications for modern-day coding, sets it apart as this generation "virtual Einstein". With Chat-GPT as a supportive tool, students can undoubtedly develop the analytical and problem-solving skills necessary for success in the ever-evolving computing sciences and technology field.

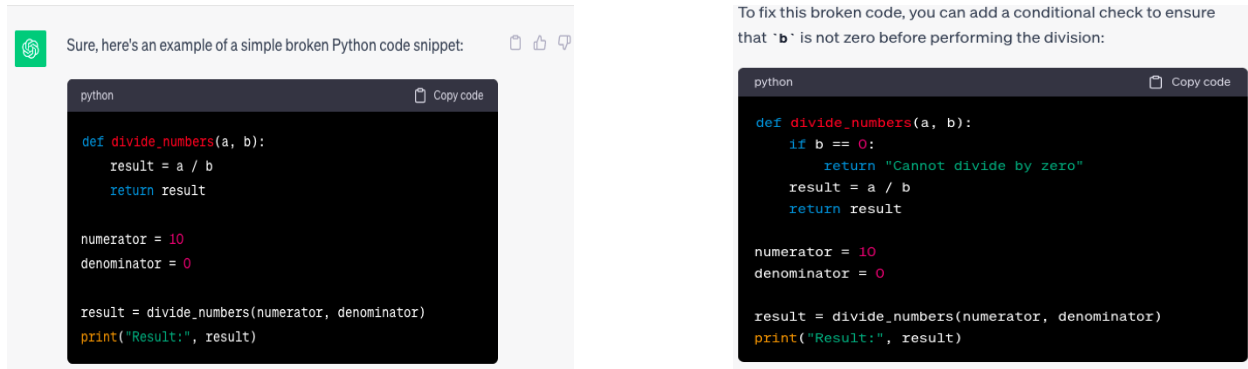


Figure 1. The above illustrates a broken code that has been amended by Chat GPT.

Figure 1 illustrates Chat GPT’s ability to troubleshoot broken code that the user has input. Just by pasting it, the AI creates an instant amended version of the code, highlighting where the issue was and why the corrected version is the appropriate solution. The ability to learn does not become nullified, and by utilizing Chat GPT in coding, students can access the specific issues in their program and apply the teaching to future programming.

Weaknesses

Chat-GPT, as an advanced AI language model, has garnered significant attention for its potential to support learning and education in computer programming. While it offers several strengths in aiding students' comprehension and problem-solving, it is essential to acknowledge its weaknesses, particularly in how it can potentially hinder the development of critical thinking skills in computer classes.

Chat-GPT operates based on patterns in its training data and may lack the depth of understanding required to engage in genuinely insightful and contextually nuanced discussions about complex computer concepts. This limitation can restrict the depth of critical thinking that students can achieve when relying solely on Chat-GPT for explanations. Because ChatGPT is trained on a large corpus of unpolished, raw data, it may not be objective, and critical inaccuracies have been reported. The efficacy of generative models hinges on the quality and diversity of the data used in their training. If these training datasets encompass biases, these biases invariably seep into the model [5]. Therefore, these generative models' efficacy hinges on the diversity of the data used in their training.

Chat GPT works on a “most accurate” response matrix that prioritizes delivering correct answers, but it does not encourage students to consider alternative working solutions from diverse perspectives. Critical thinking most times involves examining different viewpoints, whilst comparing the merit of each option from the data set, which is a human characteristic that is not a strength of AI. As a data-driven intelligence, it may not direct students to explore innovative approaches in coding because, at its core, the data output is trained to align with conformed methods that have been established. As evidenced by the work of Pavlik [6], ChatGPT is not familiar with crucial information relevant to evaluating media sources’ quality

and eventual biases. It has also been found that, in some cases, the information delivered by ChatGPT may be biased politically [5]. It is noted that AI models are not immune to biases in their training data and that without critical scrutiny, they can hinder students' ability to assess critically if their sources are unreliable.

Furthermore, students are usually encouraged to use technological resources to help nurture their learning, however an overreliance on Chat GPT can lead some to use its framework as a crutch instead of a supplementary tool to spark a general sense of direction. When students engage in AI for quick information without utilizing problem-solving and critical analysis independently, the ability to apply their skill set to complex coding may become stagnant.

While ChatGPT offers valuable support in programming classes, it does come with inherent weaknesses when it comes to nurturing students' critical thinking skills. The significant drawback is its continued tendency to provide immediate, concise answers, which can inadvertently discourage students from engaging in deep problem-solving and critical analysis. The convenience of receiving quick responses might tempt learners to seek solutions without fully comprehending the underlying logic or exploring alternative approaches. Moreover, ChatGPT's responses are based on pre-existing knowledge and may not always promote the kind of creative problem-solving and exploration essential for fostering robust programming abilities. With systems like Chat GPT being so readily available, the development of AI brings forth the question of rethinking assessment strategies in education [5].

In the realm of computer science education, the adoption of AI, like Chat GPT, has introduced a range of external considerations. These factors underscore the critical importance of ensuring the accuracy of information provided to students. AI systems, while powerful, are not infallible and can occasionally offer incomplete or even incorrect information, potentially leading students to grasp inaccurate concepts. Additionally, a heightened reliance on AI tools may inadvertently reduce the direct interactions between students and educators, which are particularly crucial for addressing individual needs and providing emotional support.

Furthermore, the potential over-automation of coding tasks through AI can pose a unique challenge. While AI can streamline certain aspects of programming, students risk missing out on essential problem-solving and debugging skills when tasks become overly automated. A disproportionate emphasis on AI assistance may also stifle creative and independent thinking among computer science students.

In response to these challenges, educators are tasked with striking a balance between leveraging AI as a valuable tool in computer science education and reinforcing the enduring value of human interaction and hands-on learning. They must also emphasize the need to critically evaluate AI-generated content and provide guidance on responsible AI use. Additionally, ongoing professional development is essential to equip educators with the skills and knowledge to integrate AI into the computer science curriculum effectively.

To respond to these weaknesses, it becomes vital to find an equilibrium between AI incorporation and traditional pedagogical approaches, advocate for conscientious AI utilization, and stimulate dialogues concerning the roles and boundaries of AI in the educational sphere.

Moreover, fostering awareness among educators and students regarding the potential for biases and ethical considerations when engaging with AI tools is of utmost importance. In conclusion, while this AI has undeniable advantages in assisting students in computer classes, dependence on Chat GPT has a significant impact on the development of critical thinking skills, which may require a supplemental approach to its use in computer learning, with a carefully selected question to provoke students to think and question the reliability of the information they are receiving from the AI.

Opportunities

Unlocking the potential of Chat GPT in the Critical Thinking application to computer learning provides opportunities for both teachers and students. This AI integration has ushered in many opportunities to enhance students' ability to think critically in learning programming.

Chat GPT creates a tailored interaction for students' individual needs by engaging in personalized learning styles, which are paced uniquely to each student. Personalization of their learning empowers students to delve deeper into concepts that navigate them towards areas of the subject matter that resonate with their unique input in the AI.

In addition, the AI offers real-time assistance with coding challenges, which creates a feedback loop that enables students to address coding issues, evaluate other solutions and evaluate consequences all in one response. This type of practical engagement has the propensity to foster critical thinking by encouraging learners to analyze programming code and make the necessary logical adjustments they require. This technology has undergone extensive training with vast amounts of data and can also be used to generate code and algorithms to fix code errors [2].

Chat-GPT's user-friendly accessibility and swift responsiveness foster a sense of inquisitiveness and an innate drive to uncover solutions. Students can boldly delve into intricate coding concepts or venture into the depths of complex algorithms without any reluctance. This atmosphere of curiosity serves as a fertile ground for the cultivation of critical thinking, guiding students through an unceasing process of inquiry, investigation, and the assimilation of knowledge.

Utilizing its expansive database and conversational prowess, Chat-GPT introduces students to a wide array of problem-solving strategies and coding methodologies. It engages in discussions about various algorithms, coding languages, and tactics, thereby fostering critical thinking. Students are prompted to use different methods, assess their respective merits and shortcomings, and discern the most fitting solution.

The capacity of Chat-GPT to furnish explanations and participate in comprehensive discussions motivates students to delve deeper into the intricacies of computer science concepts. It prompts them to scrutinize the rationale and mechanics underpinning coding practices, leading to a transition from surface-level comprehension to profound analysis.

Furthermore, Chat-GPT transcends its role as a mere tool; it serves as a facilitator of collaborative learning experiences. Students harness Chat-GPT to partake in group discussions, engage in peer reviews, and jointly tackle complex problem-solving endeavors. These

collaborative interactions not only enhance critical thinking, but also nurture effective communication and teamwork abilities, which are indispensable in the ever-evolving landscape of technology.

In addition, Chat GPT allows students to gain practical experience in a leading AI that can be used in a myriad of practical applications. Presumably, most computer science students will work in professions that utilize coding. Chat GPT provides instant troubleshooting support for broken codes no matter what the error and provides the users with the amended code and by extension a feedback mechanism that assesses the quality of the code being written. With support like this, students can become better championed in their coding with the ability to be more efficient in fixing the errors they come across. These programming hints allow students to navigate complex debugging whilst providing explanations of where they made errors; further facilitating the learning process.

Secondly, with the continued groundbreaking developments of AI, students can be encouraged to explore deeper research opportunities by studying its untapped limitations and capabilities. This type of consistent engagement with Chat GPT also fosters critical thinking by making students analyze ethical and societal implications with emphasis on the responsibility of AI development as it continues to develop. As the regulation of AI becomes more complex, trained vocational input will become paramount in navigating this new world. This further stimulates innovation in young learners to adapt to the evolving job market where AI skills are increasingly valued.

Chat-GPT is not just a technological wonder; it symbolizes a revolutionary transformation in computer-based education. Its personalized approach, instant problem-solving capabilities, and cultivation of curiosity serve as the cornerstone for nurturing a new generation of critical thinkers within the domain of computer science. By embracing the vast potential Chat-GPT offers, educators and learners alike are well-positioned to unlock the complete spectrum of critical thinking, infusing the realm of technology with groundbreaking concepts and solutions that transcend conventional boundaries and shape the trajectory of the future.

Threats

Navigating the challenges and threats of Chat GPT to critical thinking is essential to determining how much of its benefits are worth the negative challenges students may unknowingly encounter with its use. Though it offers many benefits, it is crucial to scrutinize the potential threats it poses to developing critical thinking skills among computer science students.

A significant concern associated with Chat-GPT lies in its capacity to provide instant solutions. Given its proficiency in rapidly addressing coding issues and inquiries, there is a risk that students may excessively depend on it for instant solutions. This overreliance could discourage them from actively participating in autonomous problem-solving and conducting in-depth critical analyses, thereby impeding the development of essential critical thinking abilities. Artificial intelligence, with its transformative potential, will substantially influence modern education. This is especially evident in the case of generative models like ChatGPT, which could quickly become widespread among the general population [3].

In addition, AI may unintentionally dampen students' motivation to independently delve into coding concepts. Instead of embarking on exploratory journeys within computer science, students might rely on Chat-GPT as a safety net. Such dependency could suppress their curiosity-driven learning, a pivotal element in fostering critical thinking skills.

Although Chat-GPT is a powerful tool, it is not immune to errors. Its responses are crafted from patterns within its training data, which may include inaccuracies or biases. Depending on Chat-GPT without scrutiny can result in students accepting potentially incorrect information, jeopardizing their capacity to distinguish credible sources and apply critical thinking when assessing knowledge.

Critical thinking frequently requires the application of inventive problem-solving methods. However, Chat-GPT, driven by data, may unintentionally promote conformity to established techniques, potentially dissuading students from venturing into innovative or unconventional solutions. Such constraints on creativity have the potential to impede the cultivation of well-rounded critical thinkers.

The integration of Chat GPT in computer classes presents explicit threats to students' critical thinking skills. Overreliance on Chat GPT may discourage independent problem-solving and foster a preference that defeats the purpose of learning code through comprehension. Additionally, the convenience of immediate responses could lead to a lack of perseverance in tackling challenging tasks. Moreover, concerns about plagiarism and ethical issues may undermine academic integrity. To address these threats, educators must balance Chat GPT's use as a supplementary tool while emphasizing the importance of fostering independent critical thinking, analytical skills, and ethical conduct in computer science education. Negotiating the swift transformations prompted by AI involves navigating several intricate dimensions. Foremost among these is ascertaining effective strategies to employ ChatGPT and analogous AI tools to enrich educational experiences and designing customized training modules that accommodate both teachers and students, aiming to maximize the benefits of AI tools in amplifying teaching and learning [5].

Integrating AI technologies like Chat GPT into computer science education ushers opportunities and challenges for students in this dynamic field. While AI-enhanced learning can be advantageous, it also raises concerns surrounding accessibility and educational equity. Accessibility barriers may hinder equal access to AI-powered tools, potentially engendering disparities in learning opportunities among computer science students. Furthermore, the potential for technical issues, such as system outages and connectivity problems linked to AI models, has the capacity to disrupt the learning process, accentuating the importance of addressing issues of educational equity.

The ever-evolving job market introduces a twofold challenge: graduates must equip themselves with AI-related skills, yet the automation capabilities of AI, including Chat GPT, have the potential to displace jobs in select industries. In response to these challenges, educational institutions must institute comprehensive AI policies, prioritize data privacy, offer ethical AI training, endorse responsible AI usage, and provide unwavering support to both educators and

students. It is also imperative to strike a balance between AI assistance and conventional teaching methods to ensure that computer science students cultivate indispensable skills and retain their critical thinking abilities in the face of this transformative landscape.

As the role of AI, exemplified by Chat GPT, becomes increasingly prevalent in computer science education, it brings to the fore a host of challenges and opportunities that directly impact students within this ever-evolving field. The adoption of AI in learning stands to revolutionize the education landscape, presenting benefits such as personalized learning and enhanced problem-solving abilities. Yet, it simultaneously raises concerns about accessibility and potential technical disruptions. Accessibility barriers could lead to unequal access to AI tools among computer science students, thereby jeopardizing equitable learning opportunities. Additionally, the prospect of technical glitches within AI models, such as system outages and connectivity issues, underscores the imperative to address questions of educational equity.

This symbiotic relationship between AI integration and the changing job market prompts computer science graduates to acquire AI-related skills. However, the automation capabilities of AI, including Chat GPT, are not without their consequences, potentially leading to job displacement in industries reliant on routine, rule-based tasks. Striking the right balance between AI assistance and traditional teaching methods is pivotal to ensure computer science students emerge with robust skill sets and a sharpened capacity for critical thinking in the face of AI's transformative impact.

In summary, Chat-GPT, while a valuable computer learning asset, presents challenges to critical thinking development. To leverage its advantages while addressing these concerns, educators must carefully balance the use of AI assistance with the promotion of independent problem-solving, creativity, and discernment. By striking this delicate equilibrium, the educational community can effectively navigate these challenges and ensure that Chat-GPT continues to play a constructive role in nurturing the next generation of critical thinkers in the field of computer science.

Conclusion

The integration of Chat GPT in programming education can revolutionize students' critical thinking skills, offering a wealth of opportunities while presenting challenges that must be carefully navigated. This literature review has delved into the multifaceted relationship between Chat GPT and critical thinking, shedding light on both the strengths and weaknesses of this symbiotic partnership.

Chat GPT, powered by its vast knowledge base and conversational capabilities, offers students a personalized learning experience that adapts to their individual needs. It provides real-time assistance with coding challenges, fosters curiosity, and encourages collaborative problem-solving. These strengths empower students to engage in deeper critical thinking, enabling them to analyze coding concepts, explore diverse problem-solving approaches, and apply theoretical knowledge to real-world scenarios.

However, the integration of Chat GPT is not without its challenges. There is a risk of overreliance on the AI for instant solutions, potentially hindering students' independent critical thinking development. The AI's limitations in nuanced discussions and potential biases in its responses require scrutiny. Moreover, an excessive dependence on Chat GPT can lead to a reliance on it as a crutch rather than a supplementary tool, stunting students' ability to apply their skills to complex coding challenges.

To harness the opportunities presented by Chat GPT while mitigating these threats, educators must strike a delicate balance. Chat GPT should serve as a supplementary resource rather than a substitute for critical thinking. It should encourage students to explore innovative solutions, question the validity of information, and consider alternative viewpoints. In this balanced approach, Chat GPT becomes a catalyst for nurturing critical thinking skills, rather than a hindrance.

In conclusion, Chat GPT represents a dynamic opportunity to enhance critical thinking skills in programming education across various learning phases. Its utility, when strategically integrated, fosters an enriched educational experience. However, educators must be cautious to strike a balance and mitigate the potential pitfalls, ensuring that the development of students' autonomous critical thinking skills remains at the forefront of programming education. This literature review paves the way for a more nuanced understanding of the symbiotic relationship between AI-driven tools like Chat GPT and the cultivation of critical thinking prowess in the domain of programming.

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