



REVIEW

ChatGPT in Research and Education: A SWOT Analysis of Its Academic Impact

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ABSTRACT: Advanced artificial intelligence technologies such as ChatGPT and other large language models (LLMs) have significantly impacted fields such as education and research in recent years. ChatGPT benefits students and educators by providing personalized feedback, facilitating interactive learning, and introducing innovative teaching methods. While many researchers have studied ChatGPT across various subject domains, few analyses have focused on the engineering domain, particularly in addressing the risks of academic dishonesty and potential declines in critical thinking skills. To address this gap, this study explores both the opportunities and limitations of ChatGPT in engineering contexts through a two-part analysis. First, we conducted experiments with ChatGPT to assess its effectiveness in tasks such as code generation, error checking, and solution optimization. Second, we surveyed 125 users, predominantly engineering students, to analyze ChatGPT's role in academic support. Our findings reveal that 93.60% of respondents use ChatGPT for quick academic answers, particularly among early-stage university students, and that 84.00% find it helpful for sourcing research materials. The study also highlights ChatGPT's strengths in programming assistance, with 84.80% of users utilizing it for debugging and 86.40% for solving coding problems. However, limitations persist, with many users reporting inaccuracies in mathematical solutions and occasional false citations. Furthermore, the reliance on the free version by 96% of users underscores its accessibility but also suggests limitations in resource availability. This work provides key insights into ChatGPT's strengths and limitations, establishing a framework for responsible AI use in education. Highlighting areas for improvement marks a milestone in understanding and optimizing AI's role in academia for sustainable future use.

KEYWORDS: Academic course planning; ChatGPT; educational technology; research; programming education; large language model; GPT-3; ChatGPT survey; GPT-4; artificial intelligence; SWOT

1 Introduction

Artificial intelligence has rapidly transformed various sectors over the past few decades, with education emerging as one of its most significantly impacted areas. Researchers have documented numerous ways in which AI technologies are reshaping educational systems, especially through adaptive learning, intelligent tutoring systems, and data-driven decision-making [1–4]. The integration of AI in education has led to increased efficiency in administrative tasks, personalized learning experiences, and enhanced student engagement [5–7]. A notable advancement in this domain is the development of ChatGPT and other



large language models (LLMs), which are designed to simulate human-like conversations using natural language processing techniques [8,9]. These models have the potential to revolutionize how students access knowledge and interact with educational content, particularly in resource-constrained environments [10,11]. In developing countries, where education systems often suffer from limited resources, teacher shortages, and inadequate infrastructure, tools like ChatGPT can serve as vital educational aids [12,13].

According to the World Bank (2024), a significant portion of the global education gap stems from disparities in access to qualified educators and quality learning materials [14,15]. In this context, ChatGPT can contribute meaningfully by offering on-demand tutoring, answering student queries, and generating tailored learning content in local languages [16–18]. Additionally, the model's ability to process and analyze large volumes of educational data can aid policymakers and educators in identifying performance gaps and designing targeted interventions [19]. Furthermore, ChatGPT supports inclusive education by assisting learners with disabilities, promoting self-paced learning, and providing scaffolding for complex subjects that may be otherwise difficult to grasp without expert support [20]. Such capabilities make LLMs particularly valuable in enhancing both teaching and learning outcomes in underserved regions [21].

This technology addresses challenges like instant feedback, personalized learning, and academic support, making education more accessible [22–24], especially for those with geographic or economic barriers [25,26]. Unlike traditional classrooms, where one teacher manages many students [27], ChatGPT provides personalized learning, automates teaching tasks, and supports educational policy development. Its multilingual capabilities enhance accessibility, but ethical and practical challenges must be addressed [28,29]. Maximizing ChatGPT's educational impact in developing countries requires addressing data privacy, digital access, and teacher training. Ensuring student data protection, expanding affordable internet and devices, fostering public-private partnerships, and equipping teachers with AI training is crucial for equitable integration [30,31]. Addressing these challenges can enhance education at all levels, fostering educational and economic growth [32].

Recent research increasingly investigates how students utilize ChatGPT as a learning aid across various educational settings. One study highlights how students use ChatGPT for drafting essays and solving academic queries, demonstrating both the convenience and educational support it offers [33]. Others report its use in summarizing readings, generating code, and understanding complex concepts [34,35]. Additional research points to students viewing ChatGPT as a collaborative partner in brainstorming and enhancing self-directed learning [36,37]. Furthermore, studies show that ChatGPT contributes to increased writing confidence and academic motivation among students [38–40]. Parallel studies focusing on educators reveal ChatGPT's growing role in supporting teaching routines and instructional design. Research outlines frameworks for integrating AI tools into lesson planning and administrative tasks [41]. It has also been shown to assist in preparing quizzes, adapting materials to student needs, and saving time in content development [42,43]. Another study highlights its potential to personalize learning by adjusting content complexity and style to individual learners [44]. Broader reports recognize ChatGPT's contribution to improving education systems, especially in low-resource environments [14]. While ChatGPT offers substantial advantages in enhancing learning and streamlining content creation, several challenges have been identified. Concerns have been raised about the accuracy of AI-generated information, with instances of misinformation being flagged [45]. Studies also warn of overreliance on AI, which may undermine critical thinking and result in superficial understanding [43,46]. Academic integrity is another major issue, as the tool can facilitate plagiarism if not used responsibly [47,48]. Moreover, risks related to bias and ethical concerns in AI-generated content have been discussed in several recent analyses [39,49,50]. Despite highlighting these risks, existing studies often lack detailed, context-specific analysis that could better guide educators and policymakers in effectively integrating ChatGPT into diverse educational environments [37].

Research has also examined ChatGPT's use in specific subject areas, such as Economics [51], English Language [52], Law [39], Sports Science [49], Medical Education [53–55], Higher-Order Thinking [47], Mathematics [56,57], Programming [34,58], and Software Testing [59]. However, there is a gap in understanding ChatGPT's role in programming and engineering-related subjects. Little research has focused on how engineering students specifically use ChatGPT, their motivations, or the reliability of the AI content they rely on. Addressing this gap is crucial to better understand and support the unique needs of engineering students. To address the challenges and gaps identified in prior research, our study provides an in-depth analysis of ChatGPT's use among engineering students and educators, examining how they can use the tool, their motivations, and their views on its reliability. This focused investigation sheds light on ChatGPT's unique role in engineering education, enriching our understanding of its impact in this field. Additionally, we emphasise the strategic integration of ChatGPT in education, particularly in emerging and developing countries, by analysing practical applications and their implications. The key contributions of the proposed method study are given below:

- In the study, we explore both the opportunities and limitations of ChatGPT in educational contexts through a two-part analysis. First, we conducted real-time experiments with ChatGPT to assess its effectiveness in tasks such as code generation, error checking, and solution optimization. Second, we surveyed 125 users, predominantly engineering students, to analyze ChatGPT's role in academic support.
- In the first stage, we experiment with code generation, error detection, and solution optimization with chatgpt to assess its performance and limitations in educational settings. In addition, we addressed risks like academic dishonesty and declines in critical thinking, aiming to extend beyond previous studies.
- In the second stage, we newly created a dataset in which we gathered and analyzed data from around 125 engineering students and educators to understand specific use cases, motivations, and perceptions of ChatGPT's reliability within the engineering domain. The dataset, structured around 9 survey questions, covers diverse academic tasks such as research, problem-solving, programming, and essay writing. This data-driven approach captures unique usage patterns—such as 93.60% of respondents using ChatGPT for quick academic answers and 86.40% for debugging-providing actionable insights and tailored recommendations for students, educators, and broader educational stakeholders. The collected data for the analysis is available at the following URL: <https://github.com/tusher100/chat-gpt-response> (accessed on 14 May 2025).
- Our findings offer critical guidance for policymakers, educators, and stakeholders on effectively integrating ChatGPT into educational frameworks.

2 Literature Review

ChatGPT attracts students, educators, researchers, and the general public with its in-depth knowledge across diverse subjects. Despite its benefits, concerns remain about copyright and potential misuse. To address these, researchers examine user engagement and ChatGPT's content generation for educational support and subject-specific applications. Many researchers have been conducting comprehensive analyses of ChatGPT, focusing on its use for learning and teaching, providing subject-specific solutions, and addressing concerns related to copyright and plagiarism issues. ChatGPT can act as a virtual tutor, supporting students' learning in a variety of ways. Researchers have analyzed the impact of ChatGPT on student learning, as seen in Table 1, which categorizes ChatGPT's functions into six main areas: Question Answering, Information Summarization, Exam Preparation, Draft Assistance, and Providing Feedback. Rudolph et al. [37] highlight how ChatGPT can structure discussions and guide group interactions, making debates more productive [60]. Gilson et al. [61] found that this improves problem-solving and learning outcomes. Rahman et al. [34] analyze how ChatGPT aids learners in developing programming and problem-solving skills. In assessments [62],

students use ChatGPT to refine drafts and improve content quality [61]. Its responses can encourage students to ask deeper questions, promoting critical thinking and knowledge application. However, as noted by Rudolph et al. [37], while ChatGPT is a helpful learning aid, it should complement—not replace—students' critical thinking and original work.

ChatGPT provides valuable support for teachers and instructors in both the preparation and assessment phases, as shown in Table 1. Its main applications are in teaching preparation, including generating course materials [4], offering suggestions, translating content and assessment, creating tasks, and evaluating student performance. Concerns have been raised about ChatGPT's ability to produce polished but inaccurate information, as shown in Table 2. Mogali [63] and others [43,46,49,50] highlight that ChatGPT often generates incorrect content, including fake citations, which is particularly problematic in academia, where accuracy is crucial. Megahed et al. [64] found that ChatGPT can produce flawed code without recognizing errors, a concern echoed by Jalil et al. [59], who noted its limited ability to judge its accuracy. This issue extends across fields such as mathematics [56], sports science [49], and health professions [40,63,65], raising concerns about its reliability. Another issue is ChatGPT's potential to bypass plagiarism detection. Ventayen [66] found that ChatGPT-generated essays yielded a low similarity score on Turnitin, indicating minimal detectable plagiarism. Khalil and Er [46] observed similar results, with an average similarity score of 13.72% on Turnitin and 8.76% on iThenticate, suggesting ChatGPT's text often appears original and may challenge academic integrity. To mitigate misuse, researchers propose alternative assessment methods. Zhai [42] recommends creative assignments that encourage critical thinking, while Choi et al. [48] suggests focusing on case analysis over rote knowledge recall. Geerling et al. [51] propose tasks that require students to produce AI-resistant materials, and Stutz et al. [67] emphasize higher-order skills in line with Bloom's taxonomy [68]. AI-specific plagiarism detectors also show promise in flagging AI-generated content [49], and ChatGPT's often inaccurate reference lists [40,69] can aid in identifying potential misuse. To address these issues, researchers stress the need for clear anti-plagiarism guidelines and educating students on academic integrity [37].

In addition to exploring ChatGPT's use for general student learning and teaching support, it is essential to examine its application within specific academic disciplines [70]. Discipline-specific evaluations help in understanding both the capabilities and the limitations of ChatGPT in handling subject-oriented tasks. Recent studies have assessed ChatGPT's performance in fields such as law, mathematics, and medical education, with varied outcomes across domains [71]. As shown in Table 3, most of the reviewed studies focused on higher education environments [72], with a few exceptions such as the work by de Winter, which evaluated ChatGPT's performance on high school-level examination questions [52]. In general, findings indicate that ChatGPT performs relatively well in disciplines that involve structured reasoning and interpretative analysis, such as critical thinking and economics [47]. For example, Geerling (2023) found that ChatGPT generated coherent and relevant responses to economic policy questions, demonstrating an ability to integrate conceptual understanding with real-world examples [51]. However, its performance has been notably weaker in more technical or specialized domains. In legal education, studies reported significant limitations in ChatGPT's ability to apply case law and legal reasoning frameworks effectively [48]. Similar concerns were raised regarding its performance in jurisprudential analysis and interpretation of statutes [39]. The limitations are even more pronounced in the field of medical education. Several studies have shown that while ChatGPT can provide basic medical information, it often fails in areas requiring diagnostic reasoning, clinical decision-making, and up-to-date medical knowledge [53,61]. Moreover, research has highlighted concerns about hallucinations and factual inaccuracies in medical responses, which could be detrimental in high-stakes educational or clinical settings [38,73]. Recent analyses also stress the variability of ChatGPT's outputs depending on how questions are phrased, raising concerns about consistency in medical

assessments [74–76]. Mathematics is another area where ChatGPT struggles significantly. Studies have found that although it can solve simple arithmetic or algebraic problems, it often fails with multi-step logic, abstract reasoning, or formal proof-based questions [56]. Further investigations revealed that ChatGPT tends to make procedural errors and lacks a robust understanding of mathematical syntax and logic [77]. These findings suggest that while ChatGPT shows promise in certain academic fields, particularly those that value linguistic fluency and conceptual reasoning, its limitations in technically rigorous disciplines remain a major barrier to broader adoption. Continued research is needed to refine its capabilities and evaluate how best to supplement, rather than replace, traditional methods in specialized education. Newton study [78] revealed that ChatGPT excelled in economics but scored 8 to 40 points lower than average students in other fields. In medical education, Kung et al. [53] and Gilson et al. [61] found that ChatGPT passed the US Medical Licensing Examination (USMLE) with moderate accuracy, but Fijacko [38] noted it failed the American Heart Association's life support exams. Han et al. [73] also reported incomplete information from ChatGPT on cardiovascular diseases. In Malaysia, Nisar and Aslam [35] observed that ChatGPT provided accurate pharmacology answers but lacked proper references. Similarly, ChatGPT scored below average on medical exams in China [44], Korea [79], India [80], Singapore [63], and Bangladesh [34]. Overall, these findings suggest that while ChatGPT shows promise in certain areas, its performance in medical education and other specialized fields remains limited.

Table 1: ChatGPT functions to support student learning and educators [81]

Authors	Year	Student Learning Function	Their Comments	Other Studies
Nisar et al. [35]	2023	Question and Answering	ChatGPT provided relevant, accurate answers, making it a useful tool for quick reference and self-study [35] (p. 1).	[43,61,82–84]
Pavlik et al. [36]	2023	Summarising information	ChatGPT excels at processing, distilling, and verbally presenting information [36] (p. 92).	[39,44,60]
Rudolph et al. [37]	2023	Facilitating collaboration	'ChatGPT can generate scenarios that enable students to collaborate on problem-solving and goal achievement' [37] (p. 13)	[40,60,61]
Fijacko et al. [38]	2023	Concept checking and exam preparation	ChatGPT has demonstrated potential as a strong reference and self-learning tool for preparing life support exams [38] (p. 1)	[35,48,63]
Hargreaves et al. [39]	2023	Drafting assistance	Students could be encouraged to use AI to generate a 'first draft' response, which they can then refine and improve manually [39] (p. 21)	[48,61]
Cotton et al. [40]	2023	Providing feedback	ChatGPT can be utilized to grade assignments and offer real-time feedback to students [40] (p. 2)	[43,50,85]

(Continued)

Table 1 (continued)

Authors	Year	Student Learning Function	Their Comments	Other Studies
		Teacher Related Function		
Topsakal et al. [41]	2023	Generating course materials	They queries to generate one of the dialogues in a format compatible with DialogFlow, and it completed the task [41] (p. 37)	[60,86,87]
Zhai et al. [42]	2023	Providing suggestions	They asked it that the learner had dyslexia, and ChatGPT eventually suggested specific learning materials tailored for the learner [42] (p. 1)	[64,73]
Baidoo-Anu et al. [43]	2023	Performing language translation	ChatGPT can assist in translating educational materials into various languages [43] (p. 8)	[65,85,87]
Wang et al. [44]	2023	Generating assessment tasks	ChatGPT can also generate exercises, quizzes, and scenarios to support classroom practice and assessment [44] (p. 5)	[73,87,88]
Wang et al. [44]	2023	Evaluating student performance	ChatGPT can be trained to grade student essays, allowing teachers more time to focus on other aspects of instruction [44] (p. 8)	[40,43,69]
Chang et al. [89]	2025	Professional Development	ChatGPT-based training mode (ChatGPT-TM) enhanced clinical teachers' learning achievement, self-worth, and self-confidence more effectively than the conventional training mode (C-TM). It supported reflection, reference verification, and integration of theory and practice	[90]

Table 2: Major potential issues including threat and plagiarism associated with ChatGPT [81]

Authors	Year	Issues	Representative Quotes	Other Studies
Mbakwe et al. [45]	2023	Relying on biased data	These biases arise from research conducted in high-income countries and the textbooks used to train ChatGPT [45] (p. 2)	[36,43,91]
Baidoo-Anu et al. [43]	2023	Having limited up-to-date knowledge	ChatGPT lacks knowledge of events after 2021, so it cannot provide references or information beyond that year [43] (p. 14)	[46,50,61]
Baidoo-Anu et al. [43]	2023	Generating incorrect/fake information	ChatGPT generated a fictitious article, complete with fabricated bibliographic details and a non-functional URL [43] (p. 14)	[59,63,92]
Baidoo-Anu et al. [43]	2023	Student plagiarism	Their team used ChatGPT, encountered slightly more plagiarism issues compared to the control group that did not use ChatGPT' (p. 7)	[66,69,91]
Khalil et al. [46]	2023	Bypassing plagiarism detectors	Out of the 50 essays reviewed, the plagiarism was found in 40, and that is 20% [46] (p. 10).	[37,66,67]
Susnjak et al. [47]	2023	Incorporating multimedia resources	Embedding images to exam questions can make it more difficult for students to cheat and for ChatGPT to generate accurate responses [47] (p. 16)	[37,51,78]
Choi et al. [48]	2023	Adopting novel question types	Instructors should rethink the types of questions they ask and base them on the legal rules [48] (p. 12)	[51]
Hargreaves et al. [39]	2023	Employing digital-free assessment formats	Teacher can make Blanket solution in all assessments of the 'in-class' variety and that not possible in ChatGPT for some condition [39] (p. 19)	[47,67,80]
Szabo et al. [49]	2023	Using AI-based writing detection tools	Traditional plagiarism detectors failed to recognize AI-generated text, AI-specific detectors were able to identify it [49] (p. 2)	[47,50]

(Continued)

Table 2 (continued)

Authors	Year	Issues	Representative Quotes	Other Studies
Perkins et al. [50]	2023	Checking references	Although in-text citations and references were included, they were entirely fabricated, which provides a potential way for academic staff to detect the use of AI-generated content [50] (p. 5)	[37,40,49]
Choi et al. [48]	2023	Establishing anti-plagiarism guidelines	Administrations should rethink honour codes to address and regulate the use of language models [48] (p. 12)	[37,46,50]
Rudolph et al. [37]	2023	Providing student education	Authors recommend students stay informed about academic integrity policies, understand the consequences of academic misconduct, and receive proper training on academic integrity [37] (p. 14–15)	[36,93]

Table 3: ChatGPT-3.5 performance evaluation across various subject domains [81]

Authors	Year	Subject Domain	Overall Performance	Researcher Comments	Other Studies
Geerling et al. [51]	2023	Economics	Outstanding	ChatGPT ranked in the 99th percentile for macroeconomics and 91st percentile for microeconomics compared to students.	–
De Winter [52]	2023	English language comprehension	Satisfactory	ChatGPT's mean grade of 7.18 was similar to the average student performance in the Netherlands.	–
Hargreaves et al. [39]	2023	Law	Barely satisfactory to unsatisfactory	ChatGPT performed at the level of a C+ student and struggled most with problem-style or 'issue spotting' questions.	[48]

(Continued)

Table 3 (continued)

Authors	Year	Subject Domain	Overall Performance	Researcher Comments	Other Studies
Szabo et al. [49,94]	2023	Sports science and psychology	Unsatisfactory	ChatGPT answered some questions correctly but failed the test with a 45% score.	–
Susnjak et al. [47]	2023	Critical and higher-order thinking	Outstanding	Responses were clear, precise, and relevant to requests.	–
Frieder et al. [56]	2023	Mathematics	Unsatisfactory	ChatGPT's math abilities were significantly below those of an average graduate student.	[56]
Buchberger et al. [58]	2023	Programming	Outstanding to satisfactory	Most answers were correct and well-explained, but an assignment was graded only Satisfactory.	[64,67]
Jalil et al. [59]	2023	Software testing	Unsatisfactory	ChatGPT answered 37.5% of questions correctly, insufficient to pass a software testing course.	–
Newton et al. [78]	2023	Multiple-choice question(MCQ)-based exams across subjects	Unsatisfactory	ChatGPT failed most MCQ exams and performed worse than the average human student.	–
Fotaris et al. [95]	2023	Engineering	Effective	Introduces the Room2Educ8 framework, using ChatGPT to aid in designing Educational Escape Rooms, reducing cognitive load for educators.	–
Sanchez-Ruiz et al. [96]	2023	Mathematics	Promising	ChatGPT challenges traditional blended learning in engineering mathematics, requiring adaptations in teaching methodologies.	[97]

3 ChatGPT in Research and Education: Our Real-Time Command for Exploring Benefits and Threats

The study systematically examines the benefits and risks of ChatGPT in research and education. It focuses on four areas: opportunities and challenges for learners, educators, and researchers, as well as its use

in programming education. The approach includes experiments and surveys to collect data from students and teachers [98–101]. An abstract representation of the proposed methodology is illustrated in Fig. 1, where stage-1 is our real-time experiment for ChatGPT in research and education. This stage included the experiment for learners, educators, researchers, and programmers, which is described below:

- **Opportunities for Learners:** This section assesses ChatGPT’s ability to solve subject-specific problems and compares its answers to established solutions found in textbooks. This comparison highlights ChatGPT’s effectiveness as a learning aid.
- **Opportunities for Educators:** This section assesses ChatGPT’s capacity to assist in lesson planning, answering scientific questions, and providing explanations of complex topics like Newton’s laws and chemistry.
- **Opportunities for Researchers:** This section explore ChatGPT’s potential to aid in academic writing, idea generation, literature review, and data analysis by showcasing examples of how it can be used in research workflows.
- **Programming Learning with ChatGPT:** This section evaluate ChatGPT’s ability to explain programming concepts and provide working code, assessing its role as a tool for learning programming.

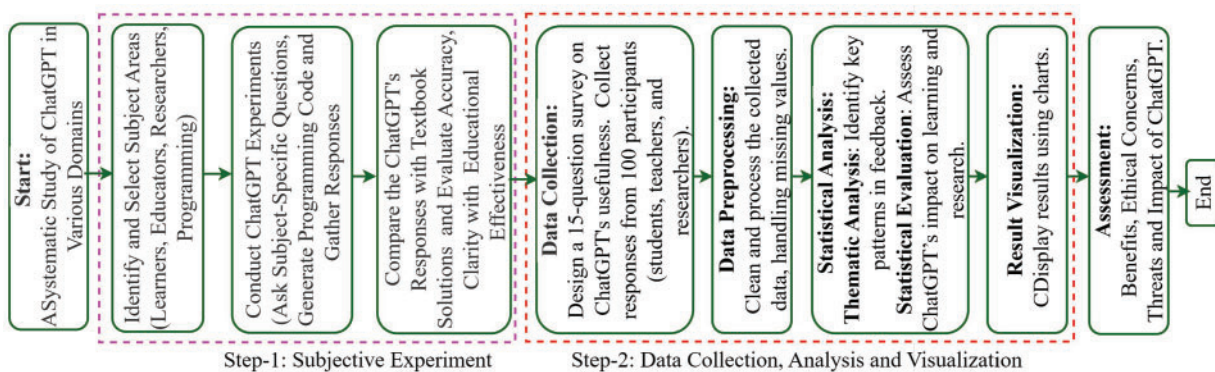


Figure 1: Abstract view of proposed methodology of ChatGPT in research and education

We categorized ChatGPT commands and queries based on user types: students, teachers, researchers, and programmers, summarizing the findings for each group. To evaluate ChatGPT’s role in education and research, we developed an experimental framework to assess its effectiveness in solving subject-specific problems, its reliability in providing educational support, and its perceived value to authors. Through these analyses, we aim to provide insights into the integration of ChatGPT in educational frameworks.

3.1 Opportunities for Learners

In this subsection, we visualize how ChatGPT enhances engineering students’ learning by simplifying complex concepts in mathematics, programming, and computer science. It offers personalized assistance, supports skill development, facilitates group discussions, and improves accessibility. By comparing ChatGPT’s responses with textbook solutions, the analysis highlights its potential as a valuable tool for mastering advanced engineering topics. The detailed procedure is illustrated in Fig. 2 Step-1.

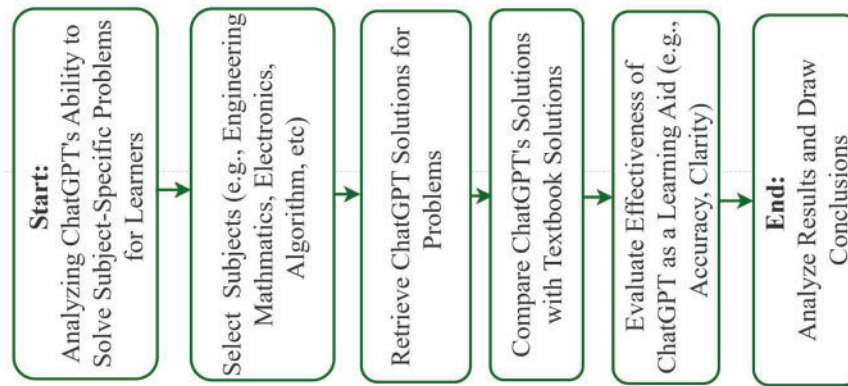


Figure 2: Opportunities and challenges for Learners with ChatGPT

3.1.1 Enhanced Learning Experience and Skill Development with Dynamic Solution

ChatGPT enhances engineering students' learning experience, especially in mathematics, programming, and computer science. It simplifies complex concepts with step-by-step explanations and real-world analogies. For instance, a student can ask for both an explanation and a code example for sorting algorithms or get a breakdown of mathematical concepts like integration. This personalized support helps learners tackle difficult topics effectively, regardless of their expertise level. For instance, a student studying QuickSort might initially struggle with understanding the partitioning process. By querying ChatGPT, they could receive an explanation like: "QuickSort works by selecting a 'pivot' element and partitioning the other elements into two sub-arrays according to whether they are less than or greater than the pivot. These sub-arrays are then recursively sorted." Additionally, ChatGPT can provide Python code for QuickSort, helping the student not only visualize but also implement the algorithm. To assess ChatGPT's practical utility for engineering students, we compared its answers to well-documented textbook solutions in two specific domains: mathematics and physics.

For example, we asked ChatGPT to solve the integral $\int x^2 \ln(x) dx$, a classic problem covered in mathematical textbooks. By comparing the ChatGPT response to the traditional local textbook solution, we can evaluate how closely it aligns with established methods and whether its explanation is suitable for learners, particularly in helping them understand the steps involved in integration. Through these analyses, we aim to showcase the advantages of using ChatGPT as an educational tool in engineering disciplines. Our findings reveal that ChatGPT is not only a resource for basic queries but also a potential guide for mastering challenging engineering concepts, making it a valuable asset for learners. ChatGPT also aids in skill development for engineering students by refining coding skills, offering code suggestions, explaining syntax errors, and suggesting alternative solutions. A student can use ChatGPT to improve code efficiency or troubleshoot bugs. In computer science, it can generate practice exercises and quizzes, helping students build problem-solving and analytical skills based on their specific needs. For instance, Imagine a student working on a Python project involving a search algorithm. The student wants to implement binary search but is unsure about their code's efficiency. They can consult ChatGPT to review their implementation and suggest improvements. In addition, ChatGPT can significantly enhance the learning experience for a beginner in programming. The code shown in Fig. 3a, provided by a Computer Science freshman, is functional and concise, calculating the factorial correctly. However, ChatGPT's response shown in Fig. 3b goes beyond functionality, incorporating several best practices that are crucial for a deeper understanding of programming.

```

int fact = 1;
printf("Enter an integer: ");
scanf("%d", &n);

for (i = n; i >= 1 ; i--) {
    fact *= i;
}
printf("Factorial of %d = %llu", n, fact);

```

(a)

```

unsigned long long fact = 1;
// Input number from user
printf("Enter a positive integer: ");
scanf("%d", &num);

// Check if the number is negative
if (num < 0) {
    printf("Factorial of negative numbers is not defined");
} else {
    // Calculate factorial
    for (i = 1; i <= num; ++i) {
        fact *= i;
    }
}

```

(b)

Figure 3: Calculate the factorial of a small integer number (a) Freshman's response (b) ChatGPT response

Moreover, ChatGPT enhances the code by adding error handling, checking for negative input, and using an appropriate data type ('unsigned long long') to handle large factorial values, preventing overflow. It also provides step-by-step comments to clarify the logic, making it easier for learners to follow. These improvements help students write professional, error-resistant, and user-friendly code, fostering better programming habits and deepening their understanding. ChatGPT serves as a valuable tool for learning and improving coding skills.

3.1.2 Enhance Accessibility of the Disabled Person as the Learner

ChatGPT enhances accessibility in education, particularly for engineering students with disabilities. Features like text-to-speech allow visually impaired students to hear coding exercises, while transcriptions help those with hearing impairments follow spoken instructions. Additionally, students can request simpler explanations of technical content, ensuring it's accessible and easy to understand for all learners. Example: A student with visual impairments working on a coding assignment can use ChatGPT's text-to-speech feature to listen to code examples and explanations, enabling them to complete the task without needing to read the text. Similarly, a student who struggles with technical jargon can ask ChatGPT to simplify complex engineering concepts, making learning more inclusive and personalized.

3.1.3 Interactive Learning and Group Discussion

ChatGPT creates an interactive learning environment where engineering students engage in dynamic conversations. For example, a student learning object-oriented programming can ask about the differences between classes and objects, followed by questions on inheritance or polymorphism. This interactive approach promotes deeper learning, providing immediate feedback and clarification, which enhances understanding and retention of complex concepts. Example 1: A student learning about circuit design can ask ChatGPT to explain the differences between series and parallel circuits. After receiving the explanation, they can then follow up with more specific questions about calculating voltage and current in different scenarios, allowing for an active, personalized learning experience that adapts to their understanding in real-time. Example 2: ChatGPT can significantly enhance the learning experience by enabling interactive learning, which helps learners understand concepts more effectively. Let's explore how ChatGPT aids this process by explaining the differences between the two code examples provided in Fig. 4a and b.

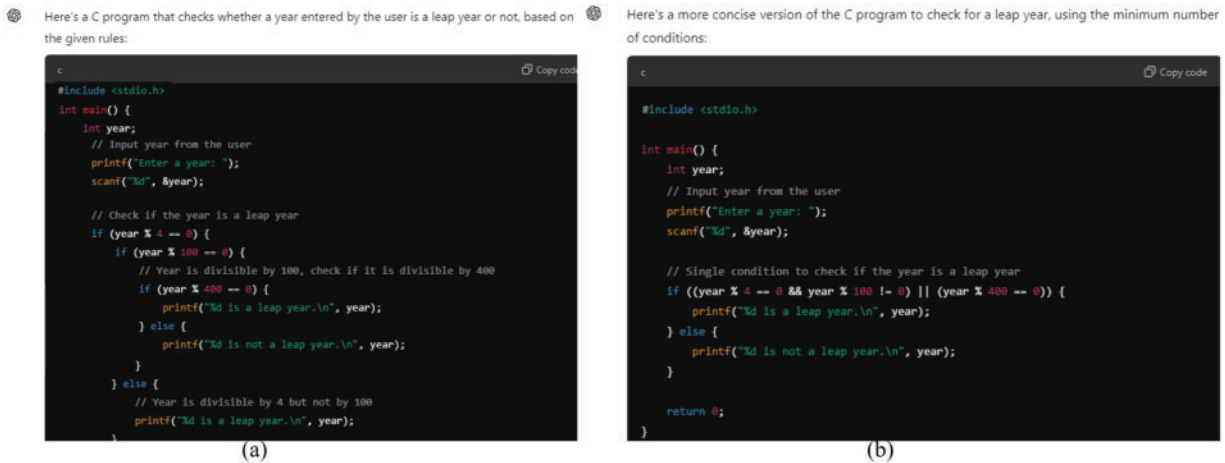


Figure 4: A C program to check leap year (a) General concept (b) Minimal number of conditions

In group projects, ChatGPT serves as a collaborative assistant by generating discussion points, providing technical data, and suggesting solutions to engineering problems. For instance, when students debate data structure efficiency, ChatGPT can break down time complexities and suggest optimal structures for specific use cases. It also helps students present arguments clearly and respond to counterpoints, improving both their technical and communication skills. Example: For instance, during a group discussion on which data structure to use for implementing a priority queue, one student suggests using a binary search tree, while another prefers a heap. To settle the debate, the group consults ChatGPT, which explains the time complexities: $O(\log n)$ for both insertion and extraction in a heap vs. $O(\log n)$ insertion but $O(n)$ extraction for a binary search tree in worst cases. Armed with this information, the group can make a well-informed decision, choosing the heap for optimal performance, and we ask ChatGPT, “Write a Python implementation of a priority queue using both a binary search tree and a heap. Compare the performance of insertion and extraction operations between the two implementations for different input sizes. Which implementation performs better for large datasets and why?”. The comparison of the two style codes shown in Fig. 4 can be explained.

- **Code Structure and Readability:** In the first code shown in Fig. 4a, the leap year check is split across multiple `if-else` statements, examining divisibility by 4, 100, and 400 sequentially. In contrast, the second code shown in Fig. 4b condenses this logic into a single line:

```
(year % 4 == 0 && year % 100 != 0) || (year % 400 == 0)
```

This concise structure enhances readability.

- **Efficiency:** Both snippets yield the same result, but the second code is more efficient, combining checks into a single `if` statement and minimizing conditional branches. The first code may perform unnecessary checks if the year is divisible by 4 but not by 100.
- **Simplicity and Maintenance:** The second code’s compact form makes it simpler to understand and maintain, while the first code’s nested structure could become harder to manage if expanded.

By comparing these snippets, ChatGPT demonstrates how coding style impacts readability and maintainability, helping learners understand efficient code practices.

3.1.4 Improvement of Assignment and Home Work

ChatGPT is a valuable tool for students, offering support across various academic subjects. It clarifies complex concepts, provides detailed explanations, and generates ideas for essays or research projects, saving time and enhancing understanding. It also helps structure assignments, improve grammar, and refine arguments for clarity. While it doesn't replace critical thinking or original research, it guides students through tasks and encourages better learning outcomes. For example, a student can ask ChatGPT to explain control statements or provide examples of loops, making difficult topics more accessible.

3.2 Opportunities for Educators

ChatGPT brings numerous benefits for educators, especially those working with engineering as educators, instructors and teachers. It helps streamline lesson planning, supports personalized learning, offers rapid assessment, and aids in responding to complex student queries. The following sections explore how educators can leverage ChatGPT to enhance teaching and improve student outcomes. Refer to the detailed process shown in Fig. 5.

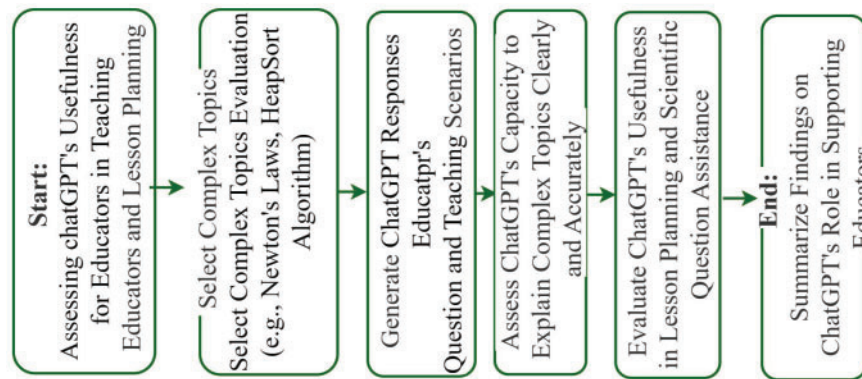


Figure 5: Opportunities and challenges for Educators with ChatGPT

3.2.1 Lesson Planning

ChatGPT brings an opportunity to make a comprehensive and efficient lesson design. One of the most time-consuming tasks for educators is developing detailed lesson plans. ChatGPT can greatly assist in generating structured lesson plans that align with curriculum goals. Example: A physics teacher could ask ChatGPT to “Design a lesson plan for a high school physics class focusing on Newton’s law. Please give me a table format and include two columns only: components and details”. ChatGPT would then provide a structured outline like Fig. 6a. In the same way, ChatGPT can assist educators across related cross-disciplines, from engineering fields to humanities: Mathematics: A math instructor could request a lesson plan on calculus, and ChatGPT would break down topics like derivatives, integrals, and limits, offering exercises that cater to both beginner and advanced students. Language and Literature: An English literature teacher could ask ChatGPT to “Create a lesson plan for teaching Shakespeare’s ‘Hamlet,’” resulting in a comprehensive guide with character analysis, thematic discussions, and historical context. By leveraging ChatGPT for lesson planning, educators can save time while ensuring their lesson plans are thorough, well-organized, and aligned with educational standards.

Grade Level: High School
 Subject: Physics
 Duration: 1 Hour

Component	Details
Learning Objectives	Define force, understand Newton's three laws, identify examples, and apply the laws to solve problems.
Materials Needed	Whiteboard, markers, projector, small objects (balls, books), worksheet, infographic on Newton's Laws.
Introduction to Force	Define force and discuss effects (change in motion, shape, direction). Engage with a question on everyday examples.
Newton's First Law	Explain Law of Inertia with examples (e.g., stationary/moving objects). Discuss real-life cases like a car stopping.
Newton's Second Law	Introduce $F = ma$ and demonstrate with objects of different masses. Practice problems on force, mass, and acceleration.
Newton's Third Law	Explain action-reaction principle with examples (e.g., pressing hands, balloon release). Discuss real-life examples like rowing or walking.
Practice Problems	Worksheet with problems covering each law. Apply laws to solve basic questions.
Review and Q&A	Summarize key points and address any student questions.
Homework Assignment	Assign questions on identifying and applying each law in everyday scenarios.

(a)

Newton's Third Law of Motion states that for every action, there is an equal and opposite reaction. This principle is fundamental in understanding rocket propulsion.

Application to Rocket Propulsion:

When a rocket engine expels gases at high speed, it exerts a force on the gases (action). According to Newton's Third Law, the gases exert an equal and opposite force on the rocket, propelling it forward (reaction).

Thrust and Equations:

- **Thrust (T):** The force that propels the rocket is given by:

$$T = m_e v_e$$

where m_e is the mass flow rate of the exhaust gases, and v_e is their velocity.

- **Acceleration (a):** The rocket's acceleration is:

$$a = \frac{T}{m_r}$$

where m_r is the rocket's mass.

As the rocket expels gases downward, it is pushed upward by an equal and opposite force, enabling it to accelerate and move forward.

(b)

Figure 6: (a) Lesson plan designing using ChatGPT (b) Application ways of scientific law

3.2.2 Adequate Teaching and Answering Queries

Educators learn at different pace to do adequate teaching, and personalized support is crucial for ensuring all learners achieve their potential. ChatGPT can be a powerful tool for personalized support by generating custom resources based on a student's specific needs. Example: Suppose a student struggles with understanding sorting algorithms in a computer science class. An educator could use ChatGPT to generate a personalized video tutorial or interactive coding exercise that focuses specifically on the types of sorting algorithms the student finds challenging. This targeted assistance helps reinforce the student's understanding and encourages active learning. ChatGPT can also be used to adapt learning materials for the teacher in real time based on a student's requirements and progress. For instance, if a student demonstrates interest in a certain topic and educators lack information about it, ChatGPT can recommend more advanced exercises or additional reading materials to help educators challenge the student further. Conversely, if an educator struggles, the model can simplify explanations, provide alternative learning methods, or offer more practice problems to build confidence and mastery. Such as an interest in any disease or the application of any scientific law. Fig. 7 shows the query of the application of Newton's law and the process of kidney disease, where ChatGPT generated some crucial information. This information can help the educator explain things to the student clearly. This personalized approach enhances educators' student engagement and promotes a deeper understanding of the subject matter. In a classroom setting, students often have questions that require immediate answers. ChatGPT can assist educators by providing accurate, detailed, and contextually relevant responses to student inquiries: Example: If a student in a physics class asks, "How does Newton's third law apply to rocket propulsion?" ChatGPT can provide a clear explanation that includes the principles of action and reaction forces, along with real-world examples such as the launch of a spacecraft. This enables students to grasp complex concepts more easily and allows educators to address a wider range of questions efficiently. Fig. 6b shows the screenshot of the question and ChatGPT response. ChatGPT's extensive knowledge base makes it particularly useful for answering specialized or complex queries that may require additional research. For example, in a biology class, a student might ask about the latest research on Clustered regularly interspaced short palindromic repeats (CRISPR) gene-editing technology. ChatGPT can provide an up-to-date summary of current advancements, ethical considerations, and potential applications, helping students stay informed about cutting-edge scientific developments. Fig. 7 shows the query and

response from the ChatGPT regarding kidney disease. By incorporating ChatGPT into the classroom, educators can ensure that student questions are addressed promptly and comprehensively, enhancing the overall learning experience.

I'm struggling with a concept "How kidney works?", could you provide simplified explanations or more practice problems?"

Simplified Explanation of Kidney Function:

1. **Function:** The kidneys filter blood to remove waste and extra substances, producing urine.
2. **Filtration:** Blood enters the kidneys via the renal arteries. In the nephrons, the glomerulus filters blood, separating waste from useful substances.
3. **Urine Formation:** Filtrate passes through tubules where useful substances are reabsorbed and waste is concentrated into urine.
4. **Excretion:** Urine moves to the collecting ducts, then to the renal pelvis, ureters, bladder, and is finally expelled through the urethra.

Practice Problem:

Describe the pathway of blood through the kidney to urine expulsion, highlighting the role of the glomerulus and nephron.

Answer:

- Blood enters through the renal artery and is filtered in the glomerulus.
- Filtrate moves through nephron tubules for reabsorption and waste concentration.
- Urine travels to collecting ducts, renal pelvis, ureters, bladder, and exits through the urethra.

Figure 7: Making practice problems with ChatGPT

3.2.3 Assessment Material Creation and Rapid Evaluation

ChatGPT can assist educators in preparing assessment materials efficiently by generating a wide range of question types, including multiple-choice questions (MCQs), short answers, and conceptual queries. Specifically, in the example provided. ChatGPT can create questions for different student proficiency levels—beginner, intermediate, and advanced—based on the topic's complexity (see Fig. 8). It ensures diverse coverage of topics, such as control statements in C, while focusing on key concepts (e.g., conditional statements, loops). ChatGPT provides answers with explanations, helping educators validate the accuracy of the questions. For example, in this "Beginner Level" question, students are asked to identify the correct syntax of an if statement in the C programming language. ChatGPT provides answers with an explanation as shown in Fig. 9a.

Here are 5 multiple-choice questions (MCQs) covering control statements in C, categorized for beginner, intermediate, and advanced students:

Beginner Level:

Which of the following is a valid `if` statement in C?

A) `if a > b:`
 B) `if (a > b)`
 C) `if [a > b]`
 D) `if {a > b}`

Answer: B) `if (a > b)`

Intermediate Level:

What will be the output of the following code?

```
int a = 10;
if (a < 5)
    printf("a is less than 5\n");
else if (a == 10)
    printf("a is 10\n");
else
    printf("a is greater than 5\n");
```

A) a is less than 5
 B) a is 10
 C) a is greater than 5
 D) No output

Answer: B) a is 10

Advanced Level:

What will be the output of the following code?

```
int i = 0;
do {
    printf("%d ", i);
    i++;
} while (i < 3);
```

A) 0 1 2
 B) 1 2 3
 C) 0 1 2 3
 D) No output

Answer: A) 0 1 2

Figure 8: ChatGPT Create questions for different proficiency levels—beginner, intermediate, and advanced

- **Option A) `if a > b:`**
This option is incorrect because the condition (`a > b`) is not enclosed in parentheses, and the colon `:` is not part of C syntax for control structures. In C, conditions must be enclosed in parentheses.
- **Option B) `if (a > b)`**
This is the correct answer. In C, the condition is placed inside parentheses, as shown here. This syntax properly follows the rules for control statements in C.
- **Option C) `if [a > b]`**
This option is incorrect because square brackets `[]` are used for array indexing in C, not for conditions in control statements. The correct syntax requires parentheses.
- **Option D) `if {a > b}`**
This option is incorrect because curly braces `{}` are used to define a block of code, not for conditions. The correct syntax requires parentheses around the condition.

(a)

Challenging Questions on Binary Trees and Graph Theory

1. Given a binary tree, write a function to perform an in-order traversal iteratively. How does this compare to the recursive in-order traversal?
2. Given the pre-order and in-order traversals of a binary tree, reconstruct the original tree. Explain the steps involved.
3. In a binary tree, find the lowest common ancestor of two given nodes. What is the time complexity of your algorithm?
4. Write a function to check if a binary tree is balanced. Define a balanced tree.
5. Compute the diameter of a binary tree. The diameter is the length of the longest path between any two nodes in the tree.

(b)

Figure 9: ChatGPT's explanations for (a) The beginning level question (b) Complex question

Educators save time on creating assessments, as ChatGPT can generate relevant questions quickly, helping streamline lesson planning and evaluation processes. Overall, ChatGPT enhances the creation of tailored, high-quality educational assessments, freeing educators to focus more on teaching and engagement. ChatGPT also brings the ability to make efficient quizzes and assignment creation, as well as automated grading and feedback for any specific topics in the engineering domain, among others. Assessment is a critical component of the educational process, but creating quizzes and assignments that accurately measure student understanding can be labour-intensive. ChatGPT can streamline this process by generating assessments tailored to specific topics and difficulty levels. Example: An educator teaching a course on data structures might ask ChatGPT to “Create a set of challenging questions on binary trees and graph theory.” ChatGPT could then generate a quiz that includes both multiple-choice questions and coding exercises designed to test a student’s comprehension and problem-solving skills. Fig. 9a shows the beginning level question-setting ability and Fig. 9b shows the question-setting ability of ChatGPT for educators. ChatGPT can also assist with grading assignments and providing feedback. For instance, after students complete a writing assignment, ChatGPT could be used to provide initial feedback on grammar, sentence structure, and content coherence. In subjects like mathematics or programming, ChatGPT could even automate the grading of assignments, ensuring accuracy and consistency while freeing up valuable time for educators to focus on interactive and creative teaching activities.

3.2.4 Teaching Materials and Slide Preparation Support

ChatGPT enhances essential writing and communication skills in engineering by providing real-time feedback on grammar, vocabulary, and phrasing. Educators can use ChatGPT to review student theses, translate reports, and offer constructive comments to improve manuscripts. Additionally, ChatGPT supports language learning through interactive exercises, allowing students to practice conversational skills via simulated dialogues. In multilingual classrooms, ChatGPT assists with translating educational materials, ensuring that all students have access to resources in their preferred language, which is especially valuable in diverse settings. ChatGPT enables educators to create more inclusive, effective learning environments and supports researchers in accelerating their work. In combination with Overleaf, ChatGPT streamlines the creation of lecture slides. ChatGPT provides structured content, ideas, and sample LaTeX code, while Overleaf’s collaborative editor supports professional-quality slide design, particularly for math-focused subjects. This partnership improves slide content and allows educators to focus more on teaching. The procedure has been shown in Fig. 10.

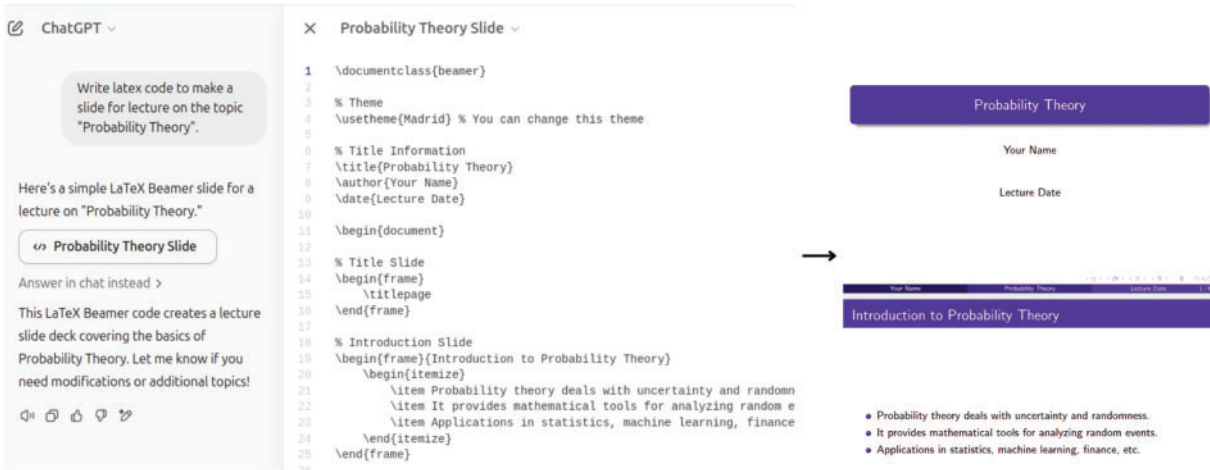


Figure 10: Lecture slide preparation with ChatGPT and Overleaf

3.3 Opportunities for Researchers

ChatGPT offers a wide array of opportunities for researchers, significantly enhancing the research process, from idea generation to publication and even system deployment. It provides support at various stages, allowing researchers to concentrate more on the core substance of their work while delegating repetitive or language-intensive tasks to AI [34,102]. For example, ChatGPT has been integrated into EEG signal analysis pipelines, real-time decision support systems, and enhanced motor imagery classification research [103,104]. It has also been used to support research in diverse areas such as crime pattern analysis, smart city development, and sentiment analysis [105,106]. These applications show that ChatGPT not only aids in content generation but also streamlines analytical and system modelling tasks. Furthermore, researchers have employed it in social signal processing and emotion recognition domains, highlighting its versatility [107,108]. Comparative evaluations of algorithms and simulation-based modelling workflows have also benefited from their automation capabilities [109]. The detailed research process supported by ChatGPT is illustrated in Fig. 11.

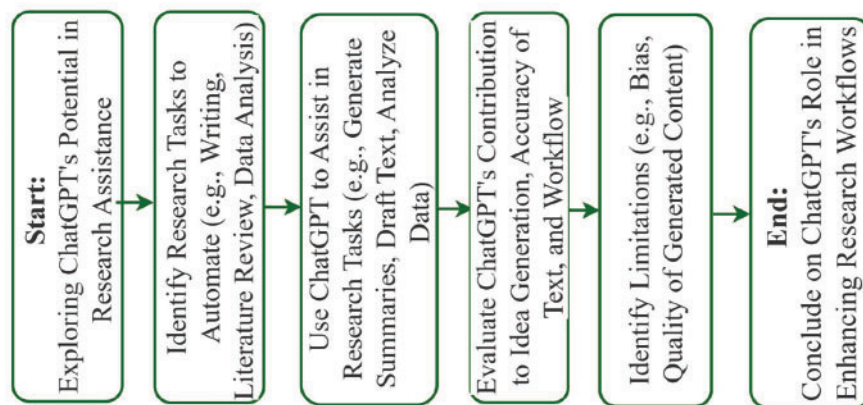


Figure 11: Opportunities and challenges for researchers with ChatGPT

3.3.1 Writing Assistance Including Existing Research with Pros and Cons

ChatGPT proves especially valuable in the writing stage by helping researchers polish and improve their manuscripts. It can identify typographical errors, resolve grammatical inconsistencies, and suggest contextually appropriate vocabulary enhancements. Furthermore, researchers can use ChatGPT to convert plain text into LaTeX format, streamlining the typesetting process and preparing documents for academic publication [110–112]. In domains such as healthcare informatics and joint signal learning, researchers have used ChatGPT to simplify the documentation of complex methods and outcomes [113–116]. It has also assisted in dynamic sign language research and multicultural hand gesture datasets by helping articulate methodology and result sections effectively [117–120]. Example 1: Suppose a researcher needs to generate a table summarizing prior work. By inputting content from relevant articles, ChatGPT can create a well-formatted LaTeX table row, as demonstrated in Figs. 12 and 13. Moreover, the AI can generate descriptive text to accompany the table, enhancing clarity and reducing manual effort, as illustrated in Fig. 14a. Example 2: Consider a researcher writing about the environmental impact of plastic waste. ChatGPT can help ensure that the manuscript is logically structured, arguments are clearly presented, and the language is refined for a scholarly tone. This support enables the researcher to focus more on data analysis and result interpretation, while ChatGPT manages the narrative flow and language quality.

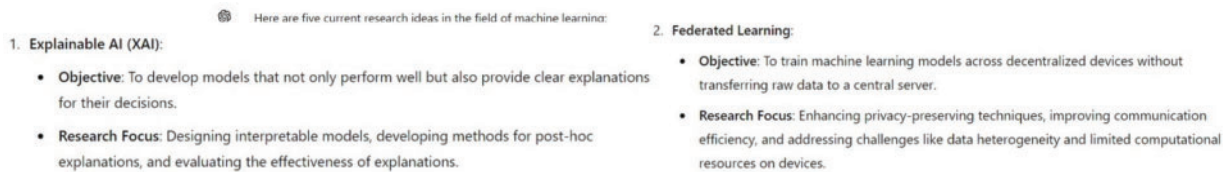


Figure 12: Current research trends queries response

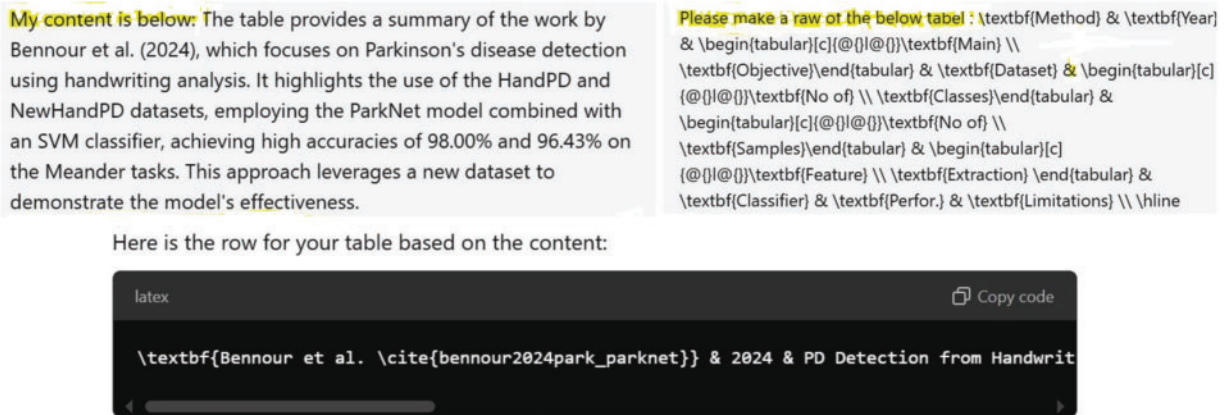


Figure 13: Making a table raw from content

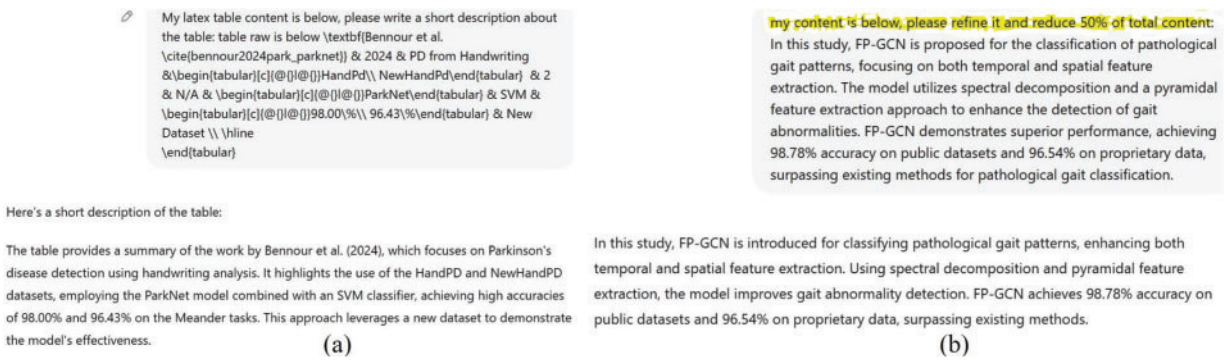


Figure 14: (a) Making content from table (b) Refine the content to reduce the words

ChatGPT can significantly support the literature review process, especially in technical and engineering domains where manual analysis of prior work is time-consuming and complex. Engineering researchers often struggle with collecting, organizing, and summarizing the growing body of scientific literature across diverse subfields. ChatGPT offers a solution by rapidly processing vast amounts of data and providing concise summaries of key findings, trends, and research gaps [121,122]. In the biomedical and signal processing domains, for instance, ChatGPT has shown promise in summarizing research related to EEG and Alzheimer's detection by parsing methodological frameworks and highlighting the evolution of machine learning approaches [123–126]. Similarly, in the field of electromyography (EMG) and motion tracking, the tool has helped identify comparative performance metrics, challenges in sensor fusion, and potential improvements in model interpretability [127]. Researchers working on spatial-temporal modeling, such as those using pose-based activity analysis, have used ChatGPT to track developments in attention mechanisms and spatiotemporal graph convolutional networks [128,129]. In areas related to sign language recognition and smart sensing, ChatGPT can streamline the comparison of cross-lingual models and dataset-specific architectural adaptations [116,130,131]. Additional studies focusing on Korean and Japanese sign language recognition also benefit from AI-generated summaries of performance trade-offs and dataset diversity [132,133]. Moreover, in earlier foundational work on motor imagery classification, ChatGPT can highlight the shift from traditional signal processing techniques to deep learning-based approaches [134,135]. These summaries not only save time but also expose researchers to interdisciplinary connections and emerging themes that manual reviews might overlook. For example, a researcher working on renewable energy can ask ChatGPT to “summarize the latest research on solar panel efficiency.” The tool may respond with a synthesis of recent innovations in perovskite materials, advancements in photovoltaic cell architecture, and gaps in long-term durability research. Such insight aids in problem identification and hypothesis formulation. Beyond summarization, ChatGPT can suggest emerging research directions. One major challenge faced by researchers across disciplines is locating the most recent publications and understanding both their contributions and limitations. ChatGPT can assist by listing the most current studies and outlining their unresolved issues, thus acting as a brainstorming partner. These “biomarkers”—in the form of known drawbacks and future work suggestions—can guide researchers toward actionable and innovative topics. For instance, if a user asks ChatGPT for unexplored topics related to “reducing errors in time-constrained programming environments,” the model may suggest the development of adaptive algorithms that dynamically reallocate computational resources based on performance metrics. This recommendation could inspire a new research trajectory focusing on real-time optimization and intelligent scheduling.

3.3.2 Data Analysis Support with Designing Flowchart

ChatGPT can assist researchers in selecting the appropriate statistical methods for their data analysis. It can explain various statistical techniques and recommend the best methods based on the research questions and the nature of the data. For instance, a survey researcher might be uncertain about which statistical tests to use. By asking ChatGPT for guidance, they could receive suggestions on the most suitable tests, such as a chi-square test for categorical data or a *t*-test for comparing means. ChatGPT is a versatile tool that can significantly enhance the research process by offering support in writing, literature review, idea generation, and data analysis. Its ability to engage in natural language conversations makes it an accessible and valuable resource for researchers across various disciplines. By leveraging ChatGPT's capabilities, researchers can streamline their workflows, generate new ideas, and ultimately produce higher-quality research.

ChatGPT can assist in designing flowcharts by providing step-by-step guidance and suggestions for visualizing processes, workflows, or algorithms. Describing the logic or sequence of actions to ChatGPT can suggest how to organize steps in a flowchart, identify decision points, and clarify the flow between tasks. Additionally, it can offer ideas for optimizing the structure and logic of the chart, making it more efficient and easy to follow. Moreover, ChatGPT can provide PlantUML code, which can be visualized using the PlantUML website, enabling users to create and view professional flowcharts in a simple, text-based format. This combination streamlines the flowchart design process, making it more accessible and customizable. The process of making a flow chart using ChatGPT and the plantuml website has been shown in [Fig. 15](#).

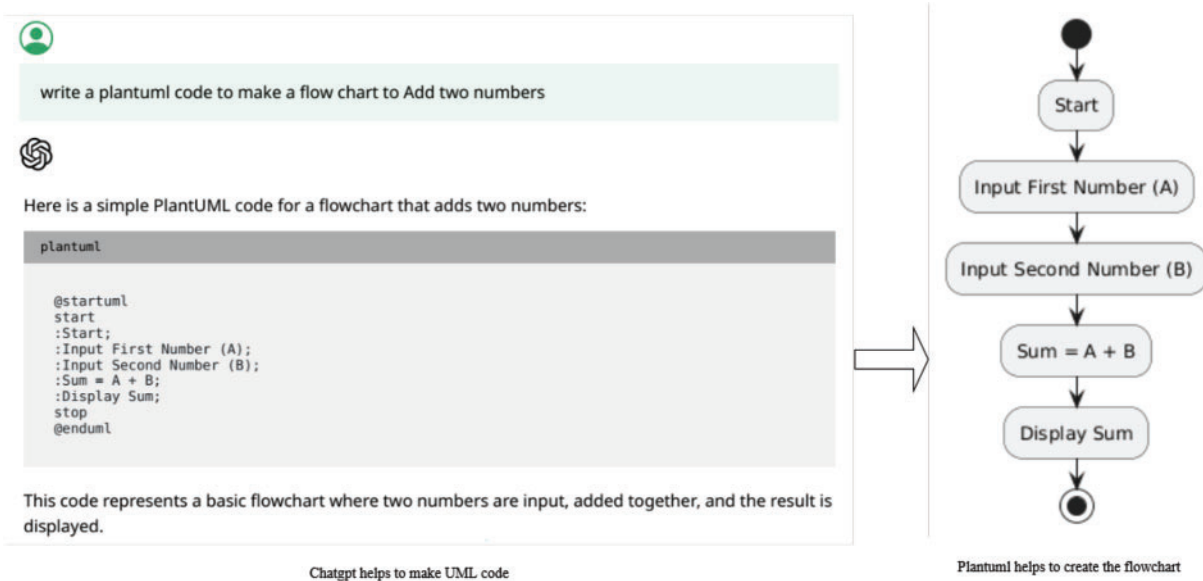


Figure 15: Chatgpt helps to design flow chart

3.3.3 ChatGPT's Role as a Research Guidance and Structuring Tool

ChatGPT is a valuable tool for researchers, assisting with the development, organization, and presentation of research work. It provides guidance on research methodologies, academic writing standards, and paper structure, enhancing clarity and cohesion [133]. For instance, ChatGPT offers specific support for beginner researchers, such as crafting focused titles, developing concise abstracts, and suggesting content for each section. It helps outline the introduction with relevant background, problem statements, and objectives and identifies key sources and knowledge gaps for the literature review. In the methodology,

ChatGPT aids in describing research design, data collection, and analysis. It also advises on objective data presentation in the results section and interpretation in the discussion. By structuring content effectively, ChatGPT enables researchers to communicate ideas. Fig. 16 shows ChatGPT's Response to the Question: Organization of a Research Article. Moreover, When writing a research paper, ChatGPT can clarify the difference between commonly confused sections, like the abstract and conclusion. It provides researchers with concise explanations, ensuring they correctly format and structure these sections Abstract: A summary of the research, including the problem, methodology, key results, and significance. Conclusion: A reflection on the results, discussing their implications, limitations, and future directions.

-  **Organization of a Research Article**
1. **Title:** Concise and descriptive title of the study.
 2. **Abstract:** Brief summary (150–250 words) of the research problem, methods, key results, and conclusions.
 3. **Keywords:** Relevant terms for indexing and searchability.
 4. **Introduction:** Background, problem statement, research objectives, and significance.
 5. **Literature Review:** Overview of existing research and identification of knowledge gaps.
 6. **Methodology:** Research design, participants, data collection, and analysis methods.
 7. **Results:** Presentation of findings without interpretation.
 8. **Discussion:** Interpretation of results, implications, limitations, and future directions.
 9. **Conclusion:** Summary of main findings and their significance.
 10. **References:** List of all cited sources.
 11. **Appendices (if necessary):** Additional material that supports the research.

Figure 16: ChatGPT's response to the question: organization of a research article

Fig. 17a shows ChatGPT's Response to the Question: Abstract vs. Conclusion. The Discussion and Analysis sections in a research paper often overlap, but each serves a unique purpose and has a distinct focus. This can sometimes confuse researchers when organizing content under these headings. ChatGPT can assist by guiding researchers on how to structure and differentiate the content in such cases, as shown in Fig. 17b. This type of guidance helps researchers avoid common pitfalls and improve the quality and structure of their academic writing.

The **abstract** is a concise summary of the entire paper, providing a brief overview of the research problem, objectives, methodology, key results, and the significance of the findings. It gives readers a quick understanding of what the paper covers. In contrast, the **conclusion** is a detailed reflection at the end of the paper, summarizing the key findings, discussing their implications, addressing any limitations, and suggesting future research directions. While the abstract provides a snapshot of the whole paper, the conclusion offers a final synthesis and interpretation of the results.

Example:

- **Abstract:** Briefly states that the paper explores the use of deep learning for ASD diagnosis, outlines the method (e.g., video analysis, XAI), highlights key results (e.g., improved classification accuracy), and summarizes the significance (e.g., potential for early diagnosis).
- **Conclusion:** Restates the problem of ASD diagnosis, summarizes how the deep learning and XAI methods addressed the issue, discusses the broader implications for clinical practice, mentions any limitations (e.g., dataset size), and suggests future research directions (e.g., expanding the dataset, testing on more diverse populations).

(a)

The **Discussion** section and the **Analysis** section have some overlap, but they serve different purposes and have distinct focuses in a research paper.

Key Differences:

1. **Focus and Purpose:**

- **Analysis Section:** Primarily centers on interpreting the results in a technical sense, providing detailed insights into what the data shows, how the models performed, and explaining patterns, behaviors, or relationships discovered in the results. It answers "what did we find?" and often includes a breakdown of metrics and observations.
- **Discussion Section:** Goes beyond the results to interpret the significance and implications of the findings. It involves critical thinking and often addresses broader questions like "what do these findings mean?", "how do they fit into the wider field?", and "what are the practical, clinical, or societal implications?". It also reflects on limitations, possible improvements, and future work.

(b)

Figure 17: ChatGPT's response to the question: (a,b) Analysis section vs. Discussion section

3.3.4 Assist in Writing LaTeX Codes for Papers

ChatGPT is an effective tool for writing LaTeX code when preparing academic papers. It assists users in formatting documents according to specific journal or conference guidelines, offering code snippets for sections like title pages, abstracts, citations, references, figures, tables, and equations. ChatGPT also recommends LaTeX packages to enhance functionality and aesthetics, such as managing complex layouts, cross-referencing, and handling bibliographies with BibTeX. From structuring the paper to debugging errors,

ChatGPT streamlines the LaTeX process, saving time and minimizing common frustrations. Using ChatGPT with Overleaf, users can quickly create LaTeX templates tailored to IEEE or Springer formats by requesting sample code with commands like, “Write a sample LaTeX code for IEEE or Springer conference paper format.”

3.4 Programming Learning with ChatGPT

In the rapidly evolving field of computer science, programming is crucial for both academic and professional success. Mastery of programming languages and concepts requires regular practice and a strong conceptual foundation. ChatGPT, with its Transformer-based architecture, provides valuable support for programming education through code generation, error detection, and optimization. The detailed process is illustrated in Fig. 18.

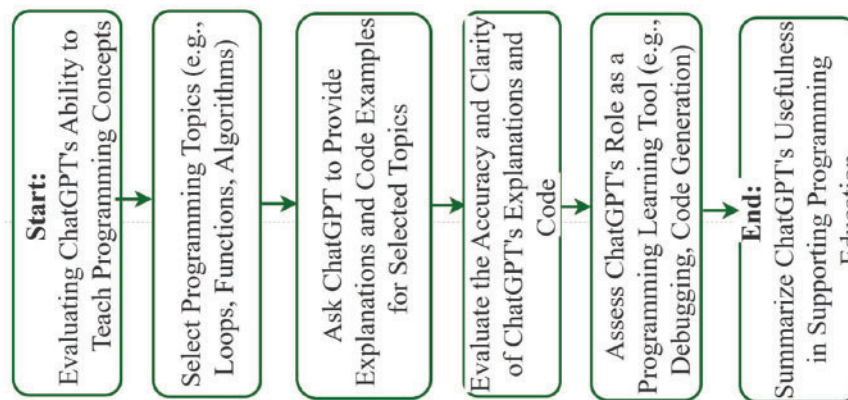


Figure 18: Opportunities and challenges for programmers with ChatGPT

3.4.1 Conceptual Understanding

Mastering programming requires a strong grasp of core concepts like variables, loops, functions, data structures, and algorithms. ChatGPT effectively breaks down these topics into easily understood explanations tailored to the learner’s level. For example, if a beginner is struggling with a “for loop,” ChatGPT can offer a simple explanation along with a basic Python example. ChatGPT also handles advanced topics like object-oriented programming (OOP), recursion, and dynamic programming. For instance, when asked about “polymorphism” in OOP, ChatGPT explains how it allows objects of different classes to be treated as objects of a common superclass, with appropriate methods called based on the actual class at runtime. Additionally, ChatGPT aids in understanding algorithms by providing pseudocode and a step-by-step breakdown, which helps learners visualize the process before coding. For example, in “merge sort,” ChatGPT can generate pseudocode and explain the divide-and-conquer strategy used in the algorithm.

3.4.2 Solution Code Generation

ChatGPT can generate complete code solutions based on a problem description, making it particularly helpful for learners needing guidance on coding approaches. It can produce code in languages like Python, Java, C++, and more. For example, if a learner is tasked with creating a program to calculate the Fibonacci sequence, they can ask ChatGPT to generate the code. ChatGPT also adjusts code complexity based on the user’s level. For beginners, it might suggest a simple iterative solution; for advanced users, it could provide a recursive approach or introduce memoization for optimization. This feature is invaluable in educational settings, especially in competitive programming, where learners must implement algorithms efficiently.

ChatGPT can quickly generate solutions that learners can analyze and refine to deepen their understanding and coding skills.

3.4.3 Error Detection and Optimization

Debugging and identifying errors is one of the toughest aspects of programming. ChatGPT can assist learners by spotting both syntax and logical errors in their code. Analyzing the provided code can pinpoint issues and suggest corrections. For example, if a student encounters a “TypeError” in their Python function, they can paste the code into ChatGPT along with a description of the error. ChatGPT would then analyze the code, identify the root cause, and recommend a fix, such as adjusting the data type or modifying a function call. Fig. 19 shows the error detection from a program.

```

1 def selection_sort(arr):
2     n = len(arr)
3     for i in range(n):
4         min_idx = i
5         for j in range(i + 1, n):
6             if arr[j] < arr[min_idx]:
7                 min_idx = j
8
9         arr[i + 1], arr[min_idx] = arr[min_idx], arr[i]
10
11     return arr
12
13
14 arr = [64, 25, 12, 22, 11]
15 sorted_arr = selection_sort(arr)
16 print("Sorted array:", sorted_arr)
17
Traceback (most recent call last):
  File "c:\Users\Tusher\Untitled-1.py", line 15, in <module>
    sorted_arr = selection_sort(arr)
                  ~~~~~
  File "c:\Users\Tusher\Untitled-1.py", line 9, in selection_sort
    arr[i + 1], arr[min_idx] = arr[min_idx], arr[i]
    ~~~~~
IndexError: list assignment index out of range

```

```

def selection_sort(arr):
    n = len(arr)
    for i in range(n):
        min_idx = i
        for j in range(i + 1, n):
            if arr[j] < arr[min_idx]:
                min_idx = j

        arr[i + 1], arr[min_idx] = arr[min_idx], arr[i]

    return arr

arr = [64, 25, 12, 22, 11]
sorted_arr = selection_sort(arr)
print("Sorted array:", sorted_arr)
Traceback (most recent call last):
  File "c:\Users\Tusher\Untitled-1.py", line 15, in <module>
    sorted_arr = selection_sort(arr)
                  ~~~~~
  File "c:\Users\Tusher\Untitled-1.py", line 9, in selection_sort
    arr[i + 1], arr[min_idx] = arr[min_idx], arr[i]
    ~~~~~
IndexError: list assignment index out of range

solve the error

```

The error occurs because the code tries to access an element at 'arr[i + 1]', which goes out of the list's bounds when 'i' is at the last index of the list. This raises an 'IndexError'.

The Problem:

The code is incorrectly attempting to swap the element at index 'i + 1' instead of index 'i'. In the last iteration, 'i + 1' will be out of the range of the list, leading to the error.

How to Fix It:

You should swap the element at index 'i' with the element at 'min_idx' (which is the correct minimum element's index). Here's the corrected code:

Corrected Selection Sort Code:

```

python
def selection_sort(arr):
    n = len(arr)
    for i in range(n):
        min_idx = i
        for j in range(i + 1, n):
            if arr[j] < arr[min_idx]:
                min_idx = j

        # Correct swap
        arr[i], arr[min_idx] = arr[min_idx], arr[i]

    return arr

# Example usage:
arr = [64, 25, 12, 22, 11]
sorted_arr = selection_sort(arr)
print("Sorted array:", sorted_arr) # Output: [11, 12, 22, 25, 64]

```

Explanation of the Correction:

- **Correct Index Swap:** The correct swap should be 'arr[i], arr[min_idx] = arr[min_idx], arr[i]'. This ensures that the minimum element found is placed at the correct position 'i'.
- **Avoiding Index Error:** By swapping the element at 'i' instead of 'i + 1', we avoid going out of bounds, thus preventing the 'IndexError'.

This corrected code will now sort the array as expected without any errors.

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Figure 19: Query: Error detection

ChatGPT provides valuable guidance on coding best practices, such as using clear variable names, commenting code, and following style guides like PEP 8 in Python. It also suggests optimizations to improve performance, such as reducing time complexity and memory usage. For example, if a student uses bubble sort ($O(n^2)$) to sort an array, ChatGPT might recommend quicksort, with a more efficient average time complexity of $O(n \log n)$. As learners work on coding problems, they can refine solutions

with ChatGPT's real-time feedback, improving both code quality and their understanding of key concepts. ChatGPT supports all aspects of programming education, from foundational learning to advanced problem-solving, by explaining concepts, generating code, detecting errors, and suggesting improvements. As a tutor, code generator, and debugging assistant, ChatGPT makes programming more accessible and engaging for learners at all levels.

4 Methodology of Analysis with Our Newly Created Dataset

In the study, we newly created and analyzed a dataset from 125 engineering students and educators to understand specific use cases, motivations, and perceptions of ChatGPT's reliability within the engineering domain. The study aimed to evaluate ChatGPT's effectiveness in solving subject-specific problems, its reliability in providing educational support, and its perceived value among users. A comprehensive experimental framework was designed, which included subjective problem-solving experiments across subjects like mathematics, programming, and electronics, where ChatGPT's solutions were compared with traditional textbook answers. Surveys were distributed to students and teachers to assess ChatGPT's impact on learning, research assistance, and programming education, measuring perceived learning improvement, ease of understanding, and information reliability. Data was collected from engineering students and teachers through surveys with 9 questions targeting ChatGPT's role in research, problem-solving, programming, and essay writing. Feedback from students, teachers, and researchers was gathered on ChatGPT's ability to enhance understanding, aid in lesson planning, and support research tasks. Statistical analysis, including descriptive and thematic approaches, was used to interpret the data and provide insights into the impact of ChatGPT in education and research.

4.1 Study Design

This study utilized a quantitative survey approach to explore the impact of ChatGPT on the academic experiences of engineering students and teachers. The survey, hosted on Google Forms, included 9 questions designed to capture various aspects of ChatGPT usage, particularly in academic tasks like research, problem-solving, programming, and essay writing. The survey's objective was to assess the perceived benefits, challenges, and overall effectiveness of ChatGPT in an educational context. The survey was conducted over two weeks, gathering responses from participants across different academic stages.

4.2 Sample

The sample consisted of 125 participants from engineering backgrounds, comprising both students and teachers. The student respondents were categorized based on their academic standing, ensuring a diverse pool of experiences from different stages in their academic journey. The distribution of students was as follows: 18.5% from the 1st semester/year, 27.2% from the 2nd year, 14.8% from the 3rd year, 23.5% from the 4th year, and 16% of respondents who had completed their studies. This wide representation ensured that the study captured a holistic view of ChatGPT's role across varying levels of experience with academic challenges.

4.3 Data Collection

The data were collected via a 9-question survey administered through Google Forms. The questions covered a range of topics, including the frequency of ChatGPT use, its role in solving academic problems, and specific tasks for which it was most useful. We collected the dataset from students and teachers with engineering backgrounds. Data collection involved students, graduates, and teachers. Of the students, 18.5% from the 1st semester/year, 27.2% from the 2nd year, 14.8% from the 3rd year, 23.5% from the 4th year, and 16% of respondents who had completed their studies. The survey included post-interaction feedback to

evaluate ChatGPT's impact on understanding, problem-solving, and its value as a learning tool for students. Teachers evaluations on how ChatGPT assisted with lesson planning, question answering, and explaining complex topics. Multiple-choice and open-ended questions to identify areas of value and gather suggestions for improvement.

4.4 Statistical Analysis of Newly Collected Data

The data were analyzed using both quantitative and qualitative methods. Descriptive statistics, such as percentages and frequency distributions, summarized responses from the Likert scale and multiple-choice questions. Comparative analysis highlighted differences between students and teachers in their use of ChatGPT. Thematic analysis of open-ended responses identified key trends and suggestions for improvement. Graphs and tables were used to represent the findings for easier visual interpretation.

4.5 Results

After analyzing the newly collected dataset, we created a dataset by collecting data from university engineering students, ensuring a diverse and well-structured dataset for our research. We generated several statistical outputs in ratios and visualization figures, which are presented below.

4.5.1 General and Research-Based Findings

Table 4 and Fig. 20 show the general findings of the data analysis. The survey revealed that 93.6% of respondents had used ChatGPT to get quick answers to academic questions, demonstrating its widespread adoption as a tool for immediate problem-solving. The largest group of users came from 2nd-year students (19.2%), suggesting that early-stage university students are particularly likely to explore AI tools like ChatGPT for academic help. Only 6.4% of participants indicated that they had not used ChatGPT for academic queries, underscoring its role as a go-to resource. 84% of respondents found ChatGPT helpful for sourcing research materials, while 16% experienced difficulties with the reliability of the sources provided. Additionally, 88% of students reported using ChatGPT to generate ideas for essays or writing assignments, indicating its significant role in assisting with brainstorming and overcoming writer's block. However, feedback highlighted a need for more accurate and reliable references, with some students reporting that ChatGPT occasionally produced fake or incomplete citations.

Table 4: Survey on how ChatGPT helps students

Number	Question	Yes (%)	No (%)
Q1	Have you used ChatGPT to get quick answers to your academic questions?	93.60%	6.40%
Q2	Has ChatGPT helped you find reliable sources for your research projects?	84.00%	16.00%
Q3	Have you used ChatGPT to solve complex mathematical equations?	59.20%	40.80%
Q4	Have you used ChatGPT to generate ideas for essays or writing assignments?	88.00%	12.00%
Q5	Have you used ChatGPT to understand complex scientific concepts in subjects like physics or chemistry?	56.80%	43.20%

(Continued)

Table 4 (continued)

Number	Question	Yes (%)	No (%)
Q6	Has ChatGPT helped you complete your lab reports or scientific research?	79.20%	20.80%
Q7	Have you used ChatGPT to debug your programming code?	86.40%	13.60%
Q8	Have you received help/support from ChatGPT to solve programming problems?	84.80%	15.20%
Q9	Are you using paid ChatGPT?	40%	96.00%

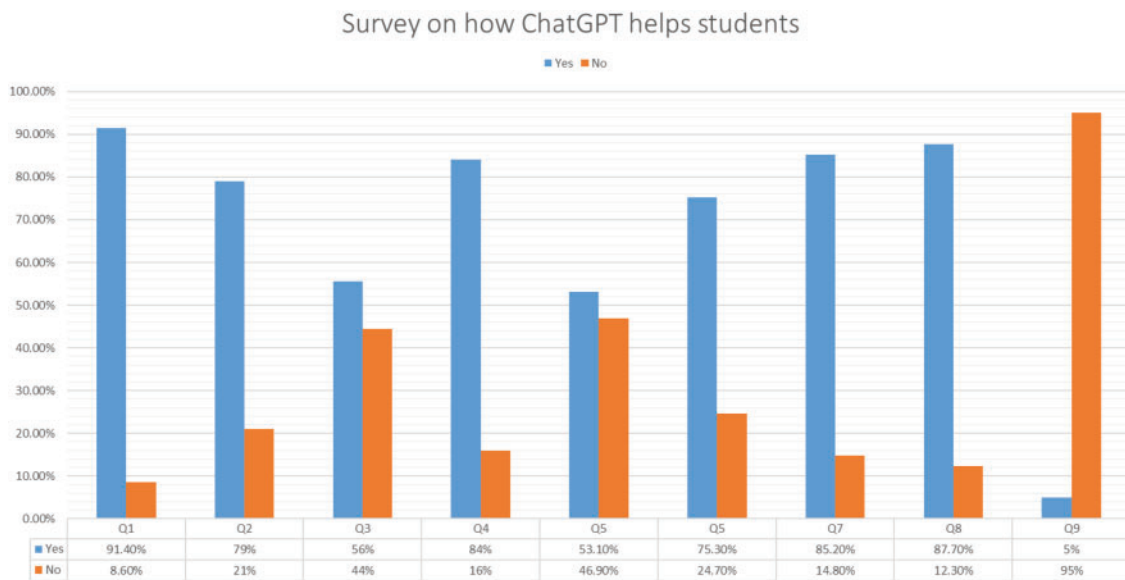


Figure 20: Survey on how ChatGPT helps students. Q1-Q9 refer to the above table

4.5.2 Use of ChatGPT in Solving Academic and Programming-Based Project Problems

When asked about ChatGPT’s role in tackling complex academic tasks, 59.20% of respondents had used it to solve mathematical equations, while 56.80% found it helpful in understanding complex scientific concepts. These results suggest a mixed level of success, with nearly half of the participants noting that ChatGPT did not fully meet their needs in more technical subjects. The respondents suggested that ChatGPT’s ability to handle advanced math and science problems required improvement. The survey highlighted ChatGPT’s strong performance in aiding programming tasks, with 84.80% of respondents using it for debugging code and 86.40% seeking support for solving programming-related problems. These high response rates demonstrate ChatGPT’s effectiveness in assisting with coding challenges, a critical area of support for engineering students.

4.5.3 Free vs. Paid Versions

One of the more surprising results came from the question regarding the use of paid ChatGPT versions. Only 4.00% of respondents were using the paid model, while 96.00% relied on the free version. This suggests

that most students find the free version adequate for their needs or that financial constraints deter them from upgrading to the paid model.

4.5.4 Feedback and Suggestions for Improvement

The open-ended responses provided several key suggestions for improving ChatGPT, including better handling of complex mathematical problems, enhanced image and document recognition features, and the addition of voice interaction capabilities. A notable number of students expressed frustration with ChatGPT providing incorrect answers, particularly in programming tasks and advanced problem-solving.

4.5.5 ChatGPT Positive Negative Review Comparison with Existing Work

Table 5 presents a comparative analysis of ChatGPT's positive and negative responses across various studies conducted in different academic domains. The comparison includes previous studies as well as our findings based on responses from engineering students. The study by Kayalı et al. [136] focused on associate degree students and reported a 65.95% positive perception and 34.60% negative perception toward ChatGPT. Indicating general acceptance but also highlighting some concerns related to incorrect information, contextual limitations, and handling of complex queries. To calculate these percentages, responses rated 4 (Agree) and 5 (Strongly Agree) were classified as positive, while responses rated 1 (Strongly Disagree) and 2 (Disagree) were classified as negative, with neutral responses (3-Undecided) excluded. Similarly, Jamil Uddin et al. [137] examined the impact of ChatGPT in civil engineering education, where the positive response rate was significantly higher at 91%, with only 9% negative feedback. However, the study by Prakasha et al. [138], conducted in the field of Computer Science Engineering, did not report specific percentages for positive or negative responses. In our study, which surveyed 125 engineering students, the overall perception of ChatGPT was 76.46% positive and 23.54% negative. We summed the total positive and negative responses across all questions and calculated the respective percentages using the formula: Positive (%) = (Total Positive Responses/Total Responses) * 100 and Negative (%) = (Total Negative Responses/Total Responses) * 100. The final percentages were determined by averaging values across all survey questions, ensuring a data-driven and accurate representation of user sentiment. These results indicate that while ChatGPT is generally well-received among engineering students, there is still a notable percentage of users who have reservations about its effectiveness. The negative responses may stem from issues such as incorrect information, lack of contextual understanding, or limitations in handling complex queries. Overall, this comparative analysis highlights that ChatGPT is widely accepted across different academic fields, with variations in perception based on the specific domain and user experience. In addition to our survey, we analyzed a Kaggle dataset [139] consisting of daily-updated user reviews and ratings for the ChatGPT Android App. This dataset provides valuable insights into user experiences and feedback over time, capturing real-world perceptions of ChatGPT's performance. The dataset includes key attributes such as user names, review content, ratings (ranging from 1 to 5), the number of thumbs-up received by each review, and timestamps indicating when reviews were posted. The data is collected from the Google Play Store and updated daily using an automated script to ensure freshness and accuracy. To maintain consistency with previous studies, we classified ratings of 4 and 5 as positive and ratings of 1 and 2 as negative, while neutral ratings (3) were excluded. Based on this classification, 91.54% of the responses were positive, while 8.46% were negative. Overall, this comparative analysis highlights that ChatGPT is widely accepted across different academic fields, with variations in perception based on the specific domain and user experience. The inclusion of real-world user feedback from the Kaggle dataset strengthens the findings, providing a broader perspective on ChatGPT's reception among both students and general users.

Table 5: Comparative analysis of ChatGPT's positive and negative responses across various studies

Author	Dataset Domain	No Sample	Positive (%)	Negative (%)
Kayali et al. [136]	Associate degree students	84	65.95%	34.60%
Prakasha et al. [138]	Computer science engineering	24	–	–
uddin et al. [137]	Civil engineering education	44	91%	9%
Kaggle [139]	General purpose	149719	91.54%	8.46%
Our	Engineering	125	79%	21%

5 Discussion: Strengths, Weaknesses, Opportunities, Threats (SWOT) Analysis of ChatGPT in Engineering Education

ChatGPT offers valuable capabilities in education and research, but also presents challenges, especially in technical fields like programming. Table 6 shows the contribution comparison of the proposed study with the state-of-the-art study. Its ability to generate human-like content raises concerns about appropriate use in these contexts. This section discusses key findings, implications for education, challenges of using ChatGPT, and potential strategies to address these issues by following Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis [140,141].

Table 6: Contribution comparison of the proposed study with state-of-the-art work

Refs.	Year	Contribution
Wu et al. [142]	2023	Key concepts, capabilities, industrial chain, and critical challenges of Artificial intelligence generated content (AIGC)
Cao et al. [143]	2023	History of generative AI and Chatgpt role in AIGC, and recent advances in unimodal and multimodal AIGC.
Zhang et al. [144]	2023	Review on ChatGPT's technologies, applications, and challenges for general-purpose AIGC.
Ray et al. [145]	2023	Review on ChatGPT development history, technologies, challenges, and future directions.
Gozalo-Brizuela et al. [146]	2023	Taxonomy of generative AI models: text-to-image, image-to-text, text-to-3D, and more.
Zhang et al. [147]	2023	Survey on graph diffusion models role in molecular, protein, and material AIGC applications.
Yang et al. [148]	2023	Review on LLMs' utilization from data, models, and downstream perspectives.
Zhou et al. [149]	2023	Survey on recent advancements in large pretrained models for text, image, and other modalities.
Zhang et al. [150]	2023	Review on fundamental technologies of AIGC, industrial applications, and development of complex tasks.
Xu et al. [151]	2023	Survey on mobile AIGC networks and cloud-edge-mobile technologies for efficient mobile services.
Wang et al. [152]	2023	Survey on AIGC architecture, security, privacy, IP protection, and regulatable paradigms.

(Continued)

Table 6 (continued)

Refs.	Year	Contribution
Wang et al. [152]	2023	Comparative analysis of language models including Google Translate, ChatGPT, and QuillBot.
Proposed work	Now	ChatGPT in Research and Education for Engineering Staff and Statistical Analysis Based on User Opinions, Including Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis

5.1 Strengths: Enhancing Learning and Academic Support

ChatGPT has demonstrated significant strengths in education, particularly for engineering students. It provides quick academic answers, assists with programming tasks, and helps students generate ideas for assignments. Our findings indicate that. (1) **Wide Adoption and Utility:** ChatGPT is widely used, with 93.6% of respondents relying on it for quick academic answers and 86.4% for debugging code. (2) **Programming Assistance:** The tool effectively supports students in coding, with 84.8% using it to solve programming problems. (3) **Accessibility:** The free version meets the basic needs of most students (96% of respondents), making it an inclusive resource for those unable to afford paid AI tools. (4) **Improved Learning Support:** Institutions can integrate ChatGPT into academic support services to enhance programming and writing skills. While these strengths highlight ChatGPT's role as a powerful AI assistant, its effectiveness in handling complex academic tasks remains an area for improvement.

5.2 Weaknesses: Limitations and Accuracy Concerns

Despite its advantages, ChatGPT has weaknesses that may impact its reliability and effectiveness in academic settings. **Inaccurate References and Citations:** Many users report issues with false citations and unreliable references, reducing trust in AI-generated academic content. (1) **Struggles with Complex Mathematics and Science:** While Chatgpt excels in text-based responses, it sometimes provides incorrect or oversimplified answers for complex mathematical and scientific problems. (2) **Over-Reliance on AI:** Students may rely too much on ChatGPT, which can weaken their critical thinking and problem-solving skills. (3) **Limited Access to Paid Features:** Only 4% of students use the paid version, meaning most users might not be benefiting from improved AI capabilities available in premium versions. (4) **Plagiarism and Ethical Concerns:** AI-generated content is increasingly human-like, making it difficult for plagiarism detection tools to identify its use in academic work. To mitigate these issues, institutions should train students on responsible AI use and explore AI-enhanced plagiarism detection tools. [Table 7](#) presents the existing study among the various language models and highlights the superior model among them. In addition, other large language models such as Gemini [153,154], Grok, DeepSeek [155,156], and ChatGPT [157] have also been explored recently. Based on the table, we can conclude that most studies have reported that ChatGPT performs worse compared to the other mentioned models.

Table 7: Comparative studies on LLM evaluation methods and superior performance

Ref.	Models compared and Other Authors	Methodology Evaluation	Results Outcomes	Superior Model	Key Findings Remarks
Lee et al. [158]	Gemini Pro vs. GPT-4V	Educational reasoning task comparison	GPT-4V outperformed Gemini Pro in accuracy and relevance	GPT-4V	Stronger reasoning and contextual understanding of educational content.
Gao et al. [159]	DeepSeek-V3 vs. Llama 3.1, GPT-4o, Claude 3.5	Benchmark tests on reasoning tasks	DeepSeek-V3 is cost-efficient	DeepSeek-V3	High efficiency, lower speed under demand.
Mondillo et al. [160]	DeepSeekMath vs. ChatGPT [161]	Reinforcement learning with chain-of-thought	DeepSeekMath is good at medical reasoning tasks	DeepSeek	Best for math, lacks general Natural language processing (NLP).
Jiang et al. [162]	ChatGPT, DeepSeek [163–165]	Scientific computing and ML benchmarks	ChatGPT is superior in coding and DeepSeek in ML tasks	ChatGPT	Best for coding, needs more power.
Sagri et al [166]	Gemini vs. ChatGPT	Assessment of AI capabilities in scientific research	Gemini scored 100%, ChatGPT-3.5 scored 70%	Gemini	Outperformed in accuracy and the scientific research process.
Rahman et al. [167]	ChatGPT, Gemini, DeepSeek [168–174]	Efficiency benchmarks for energy	Gemini is energy-efficient, DeepSeek excels in cost	Gemini (energy), DeepSeek (cost)	No overall winner; task strengths vary.
Manik et al. [175]	ChatGPT vs. DeepSeek	Python code generation using online judge challenges	Algorithmic tasks	DeepSeek	Higher correctness, fewer attempts, similar in time and memory.
Albuhairy et al. [176]	ChatGPT vs. DeepSeek	Error analysis of L2 Arabic sentences	DeepSeek better at context-driven error detection, ChatGPT instructive feedback	DeepSeek	Better at detecting semantic errors, both models need fine-tuning.
Alhur et al. [177]	ChatGPT, Gemini Advanced, Co-pilot	Review of AI applications in healthcare	GPT-4 leads in mental health support, Gemini aids in disease detection	Gemini	Significant advancements, but privacy and integration challenges remain.
Rane et al. [178]	Gemini vs. ChatGPT	Applications, performance, and architectures	Different strengths in customer service, finance, healthcare, etc.	Both models	have strengths in different domains, but architectural differences impact scalability and context.
Aydin et al. [179]	DeepSeek-V3 vs. Qwen 2.5 Max	Aacademic writing performance using AI detection tools	Both models showed high semantic overlap but lacked readability	DeepSeek-V3	High quality content generation but readability and plagiarism tests showed room for improvement.

(Continued)

Table 7 (continued)

Ref.	Models compared and Other Authors	Methodology Evaluation	Results Outcomes	Superior Model	Key Findings Remarks
de Carvalho et al. [180]	Grok, Gemini, ChatGPT, DeepSeek [181,182]	Architecture, performance, and application areas	Grok: freedom of expression, Gemini: multimodal tasks, ChatGPT: general tasks, DeepSeek: research	DeepSeek	Each model has its strengths.
Proposed model	ChatGPT	Performance, and application areas	Learning and teaching education for engineering student	79% positive response about ChatGPT	Education.

5.3 Opportunities: Improving AIs Role in Education

ChatGPT presents opportunities for educational enhancement if used strategically. Universities can integrate AI tools into their learning management systems (LMS) to provide structured academic assistance. Educators can also design AI-resistant assignments that focus on open-ended, real-world problem-solving to reduce academic dishonesty. Institutions may introduce guidelines and training programs on the ethical use of AI in learning and research to ensure responsible usage. Furthermore, OpenAI and similar platforms can improve AI reliability by refining factual accuracy and reducing bias. Future research can explore the integration of AI-powered educational platforms to balance automation and human expertise in learning environments.

5.4 Threats: Academic Integrity and AI Misuse

While ChatGPT is beneficial, it also presents threats that need proactive management. (1) Misuse in Academic Integrity: The ease of AI-generated responses makes it harder to detect cheating in online exams and assignments. (2) Challenges in AI Detection: Current plagiarism detection tools struggle to identify AI-generated content, increasing the risk [183] of academic dishonesty. (3) Dependence on AI for Critical Thinking Tasks: Over-reliance on AI tools may lead to a decline in students' ability to independently solve complex engineering problems. (4) Competition from Other AI Models: The emergence of alternatives like Gemini and Grok means ChatGPT's role in education could change as new tools offer different capabilities. To counter these threats, institutions should implement AI-awareness programs to educate students on responsible usage. Assessment redesign strategies that emphasize originality and deeper reasoning. Advanced AI detection tools to distinguish AI-generated content from human work. Using a SWOT approach highlights ChatGPT's potential and challenges in education. While it is a powerful AI tool for engineering students, addressing its limitations is crucial to maintaining academic integrity and fostering critical thinking. Educators should adapt teaching strategies to account for AI-generated content. Institutions must promote AI literacy and ethical guidelines for responsible use. Future research should focus on AI integration while minimizing risks related to accuracy, over-reliance, and academic dishonesty. By leveraging AI responsibly, ChatGPT and similar tools can enhance learning experiences without compromising the development of essential academic skills.

6 Conclusion

ChatGPT and other AI language models (LLMs) have significant potential in education and research, offering human-like conversational abilities that support answering questions, writing essays, solving problems, explaining topics, tutoring, language practice, and aiding both technical (e.g., programming, engineering) and non-technical (e.g., language, literature) disciplines. Our study contributes to the discourse on AI in education by specifically analyzing ChatGPT's impact on engineering education through real-time experiments and surveys, providing insights into its practical applications, strengths, and limitations. Despite its value in programming assistance and broader educational support, ChatGPT has limitations such as a lack of common sense, potential biases, difficulties with complex reasoning, and inaccuracies in mathematical solutions and citations, requiring users to exercise caution. The study also acknowledges constraints such as sample size limitations, self-reported data introducing response bias, and the focus on the free version of ChatGPT, which may not reflect premium features. Future research should include larger, more diverse samples, compare ChatGPT with other AI tools, and explore long-term impacts on learning outcomes. Opportunities exist to investigate AI's role in collaborative learning, ethical considerations, and policy frameworks to ensure responsible use. To maximize AI's benefits while mitigating risks, we recommend AI literacy training, ethical AI usage guidelines, curriculum integration, enhanced plagiarism detection, and increased investment in AI research and development. Addressing these aspects will enable institutions to optimize AI's role in academia, fostering sustainable and ethical AI-driven learning and research practices.

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Availability of Data and Materials: The collected data for the analysis is available at the following URL: <https://github.com/tusher100/chat-gpt-response> (accessed on 14 May 2025).

Ethics Approval: Not applicable.

Informed Consent: All participants involved in the experiment were fully informed before their participation about the purpose of the study, their right to withdraw at any time, and the confidentiality of their responses.

Conflicts of Interest: The authors declare no conflicts of interest to report regarding the present study.

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