

Essay

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Essay

Assessing the Current Performance of ChatGPT and the Implications in the Academic and Scientific Community: Failures, Misuse, and Challenges

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Abstract: Herein are reported the main pros and cons of using the conversational Artificial Intelligence (AI) called "ChatGPT" as a tool to write essays in the academic and scientific community. Also, selected mathematical and scientific problems were solved to determine the effectiveness of this platform. To this end, a systematic case study was designed and conducted to obtain data generated by the chatbot that was further analyzed. Six different topics were chosen for the essay evaluation, and the introduction section was created using this AI. Meanwhile, six mathematical problems related to integrals, z-transform, Laplace transform, and resolution of ordinary differential equations were solved. Furthermore, a scientific problem associated with the structural properties of material was also solved. After data analysis, we concluded that the conversational platform could quickly create written essays with well-structured words. Nonetheless, in almost all cases, the chatbot only used basic information to complete the introduction, and no critical writing was obtained. For the mathematical case study, we observed that under the current status of the ChatGPT, this platform has no ability or skills to solve complex equations. Thus, significant changes need to be conducted to improve the performance of ChatGPT for mathematical solutions.

Keywords: ChatGPT; Artificial intelligence; chatbot; Open AI; digital engineering

1. Introduction

In the last few months, the academic and scientific community has expressed concern about using ChatGPT (GPT is the acronym of Generative Pre-trained Transformer) and its implication in unethical behavior that results in non-original redacted manuscripts or codes [1,2]. ChatGPT is a powerful artificial intelligence chatbot introduced in November 2022 by Open AI organization and was created to interact with users through a prompt that can respond to a question in all the fields or translate text in several languages [3,4]. Furthermore, this conversational AI is too sensitive to the question written in the prompt. Users must correctly formulate their questions or try several times to obtain a positive result. This platform was trained to answer follow-up questions in a human-like way or natural language and can learn and admit its mistakes. It should be mentioned that this conversational AI model has been launched to the public for free as part of a program research trial preview [5]. Thus some questions need to be addressed such as: Is ChatGPT a risk or an opportunity for education and schools? Should teachers and universities fear be using this tool and the proliferation of similar tools? Education and technology specialists from several universities worldwide agree that there are challenges, but they also explain the panorama of change and adaption. ChatGPT took the Education sector by surprise. Today, it is ChatGPT, and tomorrow it may be another AI. So, what is essential is that we understand that the future will be uncertain and can change quickly; then, we need to be flexible and agile. In this context, Microsoft announced that it had equipped its Bing search engine with a more powerful version of ChatGPT and allowed a select

group of people to interact with it. The chatbot even went so far as to express its "desire" to be human occasionally. Experts quickly claimed that the program had no personality and could not feel emotions.

But not only in the academic field is a concern. The work sector has expressed disquiet because this AI might replace humans in the workforce [6]. Actually, programmers are worried because ChatGPT can compile any algorithm quickly. Even editors of recognized academic journals fear the potential implications of using this chatbot to write scientific papers. In this regard, Springer Nature has proposed and adopted some editorial policies, such as software to identify paper mills and plagiarism [7]. Rospligliosi mentioned the risk of misusing ChatGPT in writing essays or making students homework [8].

The information mentioned above shows that most published works are related to the disadvantages of adopting ChatGPT in the academic and scientific fields. In this work, we adopted a systematic study to demonstrate the pros and cons of this AI platform. Gordijn et al. reported that after conducting several assignments to this chatbot, they observed that this platform incurs odd mistakes like redundancy in information [1]. The latter results from an unsupervised trained model that permits learning non-validated data on the internet [5]. In this context, Stokel reported that ChatGPT uses irrelevant references, and this platform only uses previous word patterns to create a new one; in other words, there is no analysis [9]. The former can develop pitfalls in the education system that could result in the poor class interest, and students can lose their skills to write critical manuscripts. The inconvenience mentioned above in using this ChatGPT give us an idea about the concerns to detecting cheating in written essays in the academy or its misuse in the scientific field.

Indoubtedly, the COVID-19 pandemic changed our lives and hurts student education due to learning inequalities [10]. Pablo Ayala, is blunt in the context: "with the pandemic, the cost of buying jobs became much cheaper and with ChatGPT it will be almost zero cost" [11]. From the perspective of academic fraud, the tool is revolutionary, innovative. It solves things very quickly, with a high possibility that they will be well done if you give the correct instructions.

The advent of AI, such as chatbot platforms, might play a crucial role in improving education, relying on the versatility of this AI to solve step-by-step problems in mathematics, physics, modelling, and so on. Furthermore, the same app can be used by students to learn new languages or translate text. Moreover, it has been demonstrated that chatbots can develop communication skills and reduce depression and anxiety [12,13].

Therefore, this work intends to study the current performance of ChatGPT in writing essays and solving mathematical problems. In this context, six scientific topics were selected to create an introduction using this platform. The mathematical ChatGPT skills were assessed by solving six equations and one scientific issue that are commonly used in engineering courses.

2. Materials and Methods

Given the paucity of systematic research about the current performance of ChatGPT as a toolbox for self-learning and plagiarism and cheating behavior detection, here is a methodology to assess the qualities and drawbacks of this conversational platform in academic and daily scientific life. The first step of the method was defining the research questions:

RQ1: is it possible to use chatGPT to solve mathematical problems?

RQ2: is it possible to use chatGPT to generate quality essays?

RQ3: What necessary steps must be achieved to eradicate the miscues of AI?

RQ4: Is it possible to use ChatGPT to explain some concepts of mechanical properties?

To address the RQ, the study explored and managed two main possible applications of ChatGPT: assist autodidact students by solving mathematical expressions, writing essays, and explaining engineering mechanical concepts (see Table 1).

Table 1. Assessing the performance of ChatGPT by two case studies.

Case study	Dimensions	Measurement
Writing essays	Engagement of the sources, time, and information given by the platform	Level of performance according to the response.

			Detection of AI in essays, time of response,
Solving mathematical problems		Time of response, flexibility, natural language	Performance-based on the exactitude of the response
Explain mechanical concepts	engineer	Engagement of the sources, the information given by the platform, and the use of basic engineer concepts	Level of performance according to the response.

The data for the analysis was undertaken by selecting the answer given by the chatbot, performed from February 24 to March 12. The criteria for the search were conducted considering the following:

Search string: we use different paragraphs associated with mathematical procedures and questions regarding the possibility that the chatbot elucidates the solution. For example, the introduction of dye-sensitized solar cells was generated by asking: could you write an introduction of dye-sensitized solar cells using article and book references with not more than 800 words, including the reference list. Do not forget to add the references inline.

Research area: this document explores mathematical and scientific data.

To this end, we ask the chatbot to solve mathematical expressions step-by-step and write an introduction on six different topics. Table 2 summarizes the mathematical problems used to assess the chatbot's performance. The implications and advantages of the ChatGPT were determined by conducting several experiments, and the authors conscientiously analyzed the data.

Table 2. Mathematical equations used to assess the performance of the chatbot.

Function	Comments	Reference
$f'(x) = x^3 * e^{2x}$	Determine the integral of the equation	
$f = \sin(3x)$	Determine the Z transform of the mathematical expression	[14]
$f(z) = \frac{4z}{3z^2 - 2z - 1}$	Determine the inverse z-transform	[15]
1) $5 \frac{d^2x}{dt^2} + 20 \frac{dx}{dt} + 20x = 28;$ 2) $x(0) = 0, \quad x'(0) = 0$	Solve the second-order differential equation	[16]
$x(t) = e^{5t} t^3$	Take Laplace transform	[17]
$X(s) = \frac{5}{s^2(3s+12)}$	Take the inverse Laplace of the expression	[16]

All the obtained data generated by the ChatGPT platform were saved and further analyzed by the authors. For the mathematical part, the data given by the chatbot was compared and validated by solving each problem in Matlab (community and technical college license) and comparing it with the reference. Meanwhile, the AI-generated written essays were read, and then the authors critically assessed the quality of the information and the references.

It should mention here that previously published literature only generally talks about the benefits and misuse of ChatGPT rather than conducting an exploratory study [18]. Thus, this work contributes in the study of the current performance of ChatGPT, and its possible implications in the academic and scientific field.

3. Results

3.1. Case Study#1: Writing the Introduction

Using this conversational platform to generate the introduction of the proposed topics was an exciting experience. This platform wrote the introduction quickly, and the text was grammatically well-formed. The chatbot tries to write the information in a fashion way using references and

considering the word limit. Here is an extracted part of the supercapacitor introduction generated by the chatbot:

“Supercapacitors, also known as ultracapacitors or electrochemical capacitors, are energy storage devices that can store and release electrical energy rapidly and efficiently. They have attracted significant interest in recent years as a potential alternative to traditional batteries due to their high power density, fast charging and discharging rates, and long cycle life [1].

Supercapacitors consist of two electrodes separated by an electrolyte, with a porous separator between them to prevent short circuits. Unlike batteries, which store energy through chemical reactions, supercapacitors store energy through the physical separation of charge at the electrode-electrolyte interface [2]. When a voltage is applied, ions from the electrolyte are adsorbed onto the surface of the electrodes, creating a double layer of charge that stores electrical energy.

One of the key advantages of supercapacitors is their high power density, which allows them to deliver high amounts of power in short bursts. This makes them well-suited for applications that require high power output, such as electric vehicles, power tools, and renewable energy systems [3]. In addition, supercapacitors can be charged and discharged rapidly, with charging times as low as a few seconds, compared to hours for traditional batteries [4].

Nevertheless, by conducting a qualitative and conscientious analysis of the text, it can be observed that redundancy is present sometimes. For example, the first paragraph mentions that high power density is an essential supercapacitor parameter. Then, the third paragraph again said the high-power density, but no more information is given regarding the importance of this parameter in improving the efficiency of these electrochemical devices. After reading all the generated text, we concluded that the introduction is not critically constructed because only basic supercapacitor concepts were included. Not specific information is given, such as the current power density, the charge-discharge rate, stability, and the proposed materials to improve their efficiency. The latter is because some authors suggest that this platform generates biased or misleading information.

On the other hand, the chatbot used appropriate references. The only issue was that not all references were included in the list due to the limitation in words. This is relevant because O’connor states that this platform uses irrelevant references [19]. Nevertheless, because we ask to use references from articles and books, the chatbot limits its search to this kind of document.

Essay writing for students is one of the most prominent examples of where ChatGPT could become a problem. ChatGPT might not write this article well, but it feels particularly easy to use for essay writing. In studying sciences and engineering, students must read a lot to develop a thesis or research report. These manuscripts generate thoughts that will help them string together ideas, be critical, compare information, and analyze and summarize it. Finally, write in their own words a summary of everything they read; this is precisely the formative part of the student. With the excessive use of the ChatGPT, his preparation ceases to be formative and becomes more informative, so that in time he will surely have forgotten what he wrote. In contrast, if he does the test himself, he will have worked on the learning process, preparing him to face several new challenges.

One of the characteristics of human beings is their capacity for creation and mental ability. These two capabilities are possible mainly because the human brain can absorb knowledge from any object, thing, or experience and use it in the future. Thus, observation, comparison, classification, analysis, or description are necessary for learning. The most immediate processes are called basic mental processes, while others are called integrative ones. During analysis, the mind separates each component of the objects or situations observed to find their basic principles. To do so, it separates the different variables and characteristics of the whole to be analyzed. This analysis must have a final objective, such as finding the device that fits our needs. Linked to the study is the synthesis process. It is about concluding with all the information that has been acquired. This conclusion has a significant subjective element since two persons can reach different conclusions about the same object.

Thus, we suggest that this chatbot might be used for brainstorming for the student starting their research in some area.

Because ChatGPT has raised ethical concerns in universities and the scientific field, we further analyzed the text generated by this chatbot by using three different platforms to detect if the information was created by artificial intelligence (AI). Table 3 summarizes the percentage of AI used

in the text. It should be highlighted that these platforms are sensitive to the number of words used to detect the content of AI. We highly recommend using more than 200 words to guarantee good accuracy.

Table 3. Determining the AI content using different platforms.

Essay	AI content detector app (% engaged)		
	Paraphrasing tool	Draft&goal	Copyleaks
Supercapacitors (254 words)	100	100	95.6
Industry 4.0 (269)	100	99	95.7
Dye sensitized solar cell (273 words)	84	48	95.1
Artificial intelligence (278 words)	100	100	94.1
Fuel cells (352 words)	100	99	93.1
Genetic algorithms (364)	12	14	87.6
*The introduction of this work	0	0	0

To compare the versatility of this platform in determining the percentage of AI in any text, we analyzed the introduction of this work. As can be seen, all platforms suggest that a human created the introduction of this work. From Table 3 it can be observed that copyleaks and Draft&goal are the more reliable platforms for detecting the percentage of AI in the text.

3.2. Case Study#2: Solving Mathematical Problems

In this section, we analyze the results printed by ChatGPT for the proposed mathematical equations. Surprisingly, the chatbot has only one positive answer in the mathematical test, the exercise where the inverse z-transform was determined. In some cases, the answer was almost the same. For example, the first and the last mathematical expressions were integral, and the inverse Laplace was calculated, respectively.

Table 4. Comparison between the response given by the chatbot, Matlab, and the used reference.

Function	ChatGPT solution	Matlab solution	Reference
$f'(x) = x^3 * e^{2x}$	$f(x) = \frac{1}{2}x^3 e^{2x} - \frac{3}{4}x^2 e^{2x} + \frac{3}{4}e^{2x} + C$	$f(x) = \frac{e^{2x}(8x^3 - 12x^2 + 12x - 6)}{16}$	Analytically $f(x) = \frac{e^{2x}(8x^3 - 12x^2 + 12x - 6)}{16}$
$f = \sin(x)$	$f(z) = \frac{z * \sin(1)}{z^2 - 2 * z * \cos(1) + 1}$	$f(z) = \frac{z * \sin(1)}{z^2 - 2 * z * \cos(1) + 1}$	[14] $f(z) = \frac{z * \sin(1)}{z^2 - 2 * z * \cos(1) + 1}$
$f(z) = \frac{4z}{3z^2 - 2z - 1}$	$f(n) = \frac{1}{2} \left(\frac{1}{3}\right)^n + \frac{3}{2}$	$f(n) = 1 - \left(-\frac{1}{3}\right)^n$	$f(n) = 1 - (-3)^{-n}$
$5 \frac{d^2x}{dt^2} + 20 \frac{dx}{dt} + 20x = 28; \quad x(0) = 0, \quad x'(0) = 0$	$x(t) = 0$	$x(t) = \frac{7}{5} - \frac{14}{5}te^{-2t} - \frac{7}{5}e^{-2t}$	[16] $x(t) = \frac{7}{5}[1 - (2t + 1)e^{-2t}]$
$x(t) = e^{5t}t^3$	$X(s) = \frac{1}{(s-5)^4}$	$X(s) = \frac{6}{(s-5)^4}$	[17]
$X(s) = \frac{5}{s^2(3s+12)}$	$x(t) = -\frac{1}{288} + \frac{5}{12}t - \frac{7}{3}e^{-4t}$	$x(t) = \frac{5}{12}t + \frac{5}{48}e^{-4t} - \frac{5}{48}$	[16] $x(t) = \frac{5}{12}t + \frac{5}{48}e^{-4t} - \frac{5}{48}$

As is well known in the mathematical argot, two equations could be equivalent in some way. So, in order to further study the discrepancy between the results printed by the chatbot and the result obtained by Matlab the first and the last equation were plotted, and the curve behaviour was analyzed.

Figure 1a-b displays the comparison between the response of the ChatGPT and the Matlab. It can be seen that there is a significant difference in the values of each equation. So, it is concluded that the chatbot's answer is inaccurate.

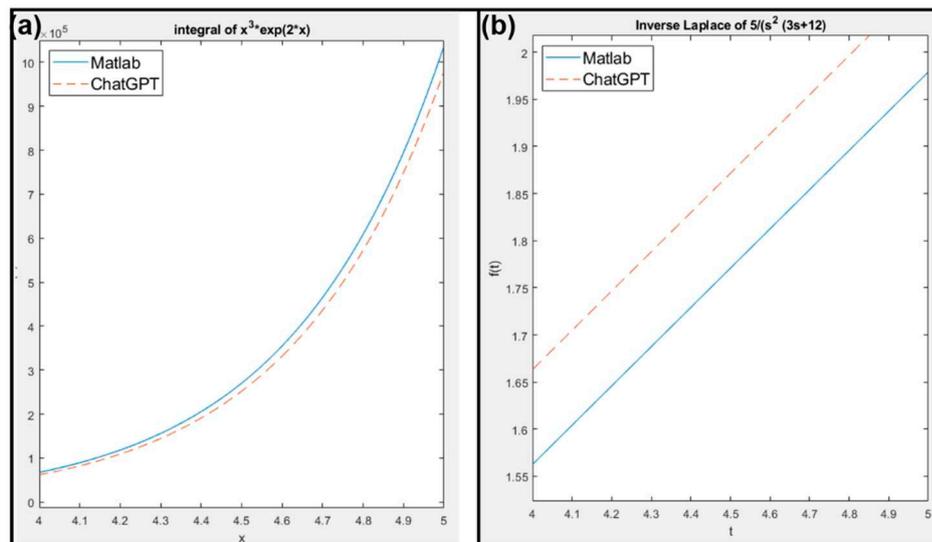


Figure 1. Comparison between the results calculated by ChatGPT and Matlab.

For the equation where inverse Laplace transforms, the chatbot has a common mistake observed in the classroom. Here is a small extract of the answer obtained:

“Yes, I can help you determine the inverse Laplace transform of $X(s) = 5/((s^2)(3s+12))$.

We can start by using partial fraction decomposition to write $X(s)$ as:

$$X(s) = A/s + B/s^2 + C/(3s+12)$$

Multiplying both sides by the denominator of $X(s)$, we get:

$$5 = A*(s^2)(3s+12) + B*(3s+12) + C(s^2).....”$$

In the third line of the above text, it is observed that the proposed form of the partial fractions is not correct because there is a repeated pole s^2 . From there on, the result will be wrong. It seems that the current status of the chatbot only permits solving easy equations, as is the case of the inverse z-transform, where a previously well-known defined methodology is applied.

Thus, it can be inferred that the chatbot has been trained under an unsupervised method resulting in a discrepancy. This outcome suggests that the platform must be improved to be implemented in the academic field. So, the expected personalized learning and tutoring experience are not ready, and a lot of work needs to be done to guarantee the successful performance of this chatbot.

The main implication of adopting the current version of the chatbot is inaccuracy in solving mathematical problems that can drastically affect students' learning performance. Meanwhile, implementing ChatGPT to create essays can motivate students and practitioners to write more critical manuscripts. Although the misuse of this tool can be detected by using different apps, we believe that in the near future, the text generated by Ai could have the same syntaxes as written by humans.

3.3 Case Study#3: Studied the Mechanical Properties of Materials

In order to know the depth of information that chatGPT can provide, we focus on a general topic on the study of the mechanical properties of materials. For them, some questions were generated in the chatbot about the information that can be obtained from a tension test, and then the chat was asked to explain how to calculate a very particular and crucial mechanical characteristic of materials such as fracture toughness. The results obtained were the following:

1. Explain the stress-strain curve. The chatGPT's response was comprehensive, clear, and quite satisfactory and presented an excellent and accurate description of this type of material curve.
2. What mechanical properties can I obtain from a tensile test? Here the answer had some omissions, certainly, the chat indicated some of the main properties that can be measured from a tensile test. But a very important one was missing, as the elastic limit and how to obtain it from the test were not mentioned. This property is perhaps the most important when working with structural materials because all design calculations are made based on this property.

3. Defines the fracture toughness of a material. Here the chat collapsed at first and could not give a definition of this type of mechanical property of materials. However, when the question was rephrased, he gave a quite an adequate definition.
4. How to calculate the stress intensity factor in a material? The answer given by the chat was only half good, since he first defined the stress intensity factor and then proposed a straightforward mathematical equation to calculate it. Many mathematical models have been proposed and validated to date to perform this calculation. Also, although the question is very generic, it does not explain how to calculate.

From here, it is clear that the way of asking questions is very important for the chat to provide adequate answers. Also, it should always be considered that the information provided by the chat may contain errors and will not always be complete. Therefore, it is essential to use it only as a support tool and not as something that will solve the task.

The results are in accordance with the asseveration made by Ayala that this platform generates inaccurate data. "I asked it to generate information for me based on articles by people talking about that topic," he relates. "It gave me an author I didn't know. And then I asked him: Does this author exist? And he said, 'No, he doesn't exist. I made him up because you asked me for a bibliography". So you must be very careful with the information requested and how it is asked.

The chatbot and its amazingly human-like responses have sparked a debate about what kind of regulation needs and who should set it. This technology, according to experts, will revolutionize working life or the search for information online. At the same time, they warn that it could put millions of people out of work or be used to misinform. This has sparked a debate about the standards needed for AI. When we ask ChatGPT, he says the answer is complex: "There are many different perspectives on this topic". But, the software continues, there is a consensus that the rules should be "jointly developed by various stakeholders and experts." This includes regulators, technology companies, researchers, non-governmental organizations, and interest groups.

4. Conclusions

This work demonstrated the advantages and disadvantages of using ChatGPT for everything where data information is digitally processed. This platform can quickly process big data volume and give us an answer related to the follow-up question written in the prompt. The mathematic case study result shows that the chatbot cannot be used as a reliable toolbox to solve any mathematical problem. So, we strongly suggest that students or practitioners have the answer to the problem in advance. So they can compare the result and critically think about the step-by-step result printed by the platform.

On the other hand, ChatGPT performs well in writing essays; some are well-structured. Because ChatGPT has raised concern in universities and the scientific field due to its imminent misuse, we propose implementing platforms that quickly detect the percentage of AI used to create any text. This is essential for institutions or universities without plagiarism and AI detection software.

It should be highlighted that professors and students must be educated on ethics and plagiarism. Because of the rapid dissemination of AI, normativity and guidelines need to be developed to avoid cheating. Lastly, it should be mentioned that this kind of AI does not replace human ability due to the lack of critical thinking. Finally, in our opinion and until now, ChatGPT will be very beneficial when we want to get our students to find answers to particular questions and solve simple problems. In contrast, it will be very challenging if we try to find answers to the solution of complex problems, and it will be even more problematic if we intend to use it as a substitute for the students' thought processing.

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. The following statements should be used "Conceptualization, WJPR and ERR; methodology, WJPR; software, ENAM, CACA and JARG.; validation, WJPR and ERR; formal analysis, WJPR; investigation, ENAM, CACA and JARG; resources, ENAM, CACA and JARG; data curation, WJPR; writing—original draft preparation, WJPR and ERR; writing—review and editing, CACA; visualization, WJPR and ERR; supervision, WJPR and ERR; project administration, WJPR and ERR; funding acquisition, ERR. All authors have read and agreed to the published version of the manuscript."

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Conflicts of Interest: The authors declare that is not any conflict of interest.

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