frontiers | Frontiers in Education

TYPE Perspective
PUBLISHED 28 February 2024
DOI 10.3389/feduc.2024.1321547

OPEN ACCESS

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RECEIVED 14 October 2023
ACCEPTED 05 February 2024
PUBLISHED 28 February 2024

CITATION
Monteiro FF, Souza PVS, da Silva MC, Maia JR, Silva WF and Girardi D (2024) ChatGPT in Brazilian K-12 science education.
Front. Educ. 9:1321547.
doi: 10.3389/feduc.2024.1321547

ChatGPT in Brazilian K-12 science education

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This study investigates the perceptions of K-12 science teachers regarding the implications of ChatGPT on school assessments and the quality of students' education. A questionnaire was administered to K-12 science teachers from public and private schools across the five regions of Brazil: North, Northeast, South, Southeast, and Midwest. More than 400 teachers responded to the questionnaire. The conclusions regarding the opinions of the teachers who responded to the questionnaire were based on the Likert-type scale. The investigation covered various aspects, including the types and frequency of assessment methods used with their students. Additionally, the research delved into their opinions on whether ChatGPT would impact the quality of education and assessment methods, as well as their views on whether ChatGPT use should be deemed plagiarism or a similar infraction. The potential benefits of its use, as well as the challenges arising from it, are discussed in the context of the evolution of teaching and learning. As one of the results, it was found that among K-12 science teachers, there remains some skepticism regarding whether ChatGPT will enhance the quality of students' education and whether its use constitutes plagiarism or a similar infraction.

KEYWORDS

ChatGPT, K-12 teachers, science education, assessment methods, teaching and learning

1 Introduction

The recently released ChatGPT has captured the attention of academics, sparking their interest in understanding its potential applications and implications (Chen et al., 2020; Firat, 2023a,b). Integrating Artificial Intelligence (AI) and Natural Language Processing (NLP) technologies in education has the potential to start a transformative era, revolutionizing teaching and learning dynamics, unlike traditional tasks like classification and regression. Among the recent technological tools applied in education, Artificial Intelligence (AI) has emerged prominently, particularly through generative AIs like ChatGPT, Bard, and others. In a study by Tavares et al. (2020) on AI in education, they conducted an exploratory review to identify trends and research in recent years. Their findings revealed that while Intelligent Tutor Systems remain a key application of AI in education, several other AI approaches are also gaining traction in the educational landscape. This new class of generative AI models uses massive datasets and advanced algorithms to simulate human-like conversations and provide

contextually relevant responses (Brown et al., 2020; Okonkwo and Ade-Ibijola, 2021). Its ability to understand and respond to written input, engage in a conversation, and provide customized interactive assistance, can improve the autodidactic students' autonomy and independence.

The potential of ChatGPT to provide personalized support, direction, and feedback can enhance autodidactic student motivation and engagement, improve writing, and produce formative assessments and literature reviews, as already mentioned by many authors (Shawar and Atwell, 2007; Sallam, 2023; Firat, 2023a,b). However, new challenges also arise, for example: How can teachers determine whether a student completed a work independently or used a generative tool? What is the acceptable limit for AI-generated content in student work before it is considered plagiarism or a similar issue? How to help students understand when the answer given by a generative AI is inaccurate?

Another important aspect is that the number of Educational Technology companies is increasing. These companies are entering the traditional education market with data-driven teaching and learning solutions. In this case, the question arises: Will some teachers be replaced by these types of generative technologies? Without a doubt, many teachers fear that technologies like GPT Chat could replace them in the future (Alam, 2021; Chan, 2023; Chan and Tsi, 2023). The future of education around the world will be greatly impacted by this type of technology (Renz and Hilbig, 2020; Ji et al., 2023; Mäkitalo et al., 2023).

Regarding the Brazilian case, the educational landscape reflects a diverse and multifaceted system comprising public and private schools, each addressing distinct regional characteristics and challenges. Despite the adoption of modern pedagogical approaches, traditional assessment methods have long dominated the evaluation process. In this scenario, as the significance of student assessments remains central to the effectiveness of educational practices, the exploration of innovative AI technologies (such as ChatGPT) presents a compelling avenue for potential advancements in this domain. There is a growing recognition that assessment strategies must evolve in line with contemporary learning paradigms.

Following this trend, the present study analyzes the perceptions of K-12 science teachers about the use of ChatGPT in the educational environment. The general objective is, albeit preliminarily, to outline the impacts and difficulties associated with the AI technologies integration into the educational context.

This text is organized in the following way: First, we present the methodological approach used in this study, including details about the data collection process. Next, the results are presented and discussed. Finally, drawing on the results, some possible implications and challenges for the educational process are presented.

2 Methodology

This study has a qualitative and descriptive nature. An online questionnaire was applied via Google Forms for K-12 science teachers, and over 400 of them responded. These teachers were from both public and private schools in the five regions of Brazil: North, Northeast, South, Southeast, and Midwest. The analyses of these data will be discussed in the next section of this work. At this point, it is important to explain the term "K-12 teachers". In Brazil, this designation refers to teachers who teach in the first 12 years of basic education, covering students aged 6–18. However, it should be noted that most of the teachers who responded to the questionnaire are physics teachers and primarily worked with students aged 12–18, and teachers who teach science to students in the last two years of elementary school, for these two classes of teachers we are using the term "K-12 science teachers". It is a crucial stage in the training of new students, preparing them for careers in science, technology, engineering, and mathematics (STEM) fields—essential for the country's economic development. However, although this study was carried out with teachers who work in K12 science education, it is also crucial to conduct similar research among university teachers, especially those involved in teacher training, such as in undergraduate physics courses. We intend to pursue this in future research. Moreover, while Brazil's K12 science education has distinct characteristics that may limit the generalizability of the conclusions presented here, we believe that our results can offer insights to teachers in other countries regarding the issues analyzed in this study.

The conclusions regarding the opinions of the teachers who responded to the questionnaire were based on the Likert-type scale. This scale, developed by Rensis Likert in 1932, is used to quantify opinions or attitudes. It involves creating a set of propositions related to a specific construct and then evaluating the degree of agreement among respondents (Meireles, 2020). The Likert scale makes use of semantic differentials that vary qualitatively in degree, ranging from the lowest point of Completely Disagree (CD) to the highest point of Completely Agree (CA). The scale can be symmetrical, with an odd number of points, and Neutrality (N) – neither agree nor disagree—exactly between the two extremes, or asymmetrical, with an even number of points, not offering the option of neutrality and requiring respondents to choose one side (Joshi et al., 2015; Monteiro, 2021). In our case, a 5-point Likert-type scale was used. The numerical values assigned to the answers reflect the strength and direction of the opinion of those respondents about the propositions.

The proposition agreement degree (PAD) interpretation related to our results is displayed in Table 1. The questionnaire explored the following main points: (1) the frequency with which the teachers use *homework assignments, exercise lists, oral presentations, online tests, or in-person tests* as methods of assessing students, (2) the impact of ChatGPT on the quality of student education and (3) assessment methods, and (4) whether teachers believe that the use of ChatGPT constitutes plagiarism or a similar infraction. The results are displayed in Tables 2, 3. Although the items listed in Table 3 are not Likert-type

TABLE 1 Interpretation of PAD related to the results presented in Tables 2, 3, based on the Likert-type scale with a 5-point format.

PAD	PAD interpretation	
	Table 2	Table 3
[80%;100%]	Weekly	Completely agree
[60%; 80%]	Monthly	Partially agree
[40%; 60%]	Bimonthly or quarterly	Neutral
[20%; 40%]	Annually	Partially disagree
[0%; 20%]	Never	Completely disagree

10.3389/feduc.2024.1321547

TABLE 2 Analysis of the degree of agreement with propositions related to the frequency with which they use *homework assignments, exercise lists, oral presentations, online tests, or in-person tests* as methods of assessing students, based on the number of responses provided.

	Semantic differential								
Question	1	2	3	4	5	TR	PA	PAD	Interpretation
Public school									
1—How often do you use *homework assignments* as a means of assessing students?	25	12	117	124	65	343	248	72%	Monthly
2—How often do you use *exercise lists* as a means of assessing the students?	12	3	23	98	198	343	308	90%	Weekly
3—How often do you use *oral presentations* as a means of assessing the students?	73	43	123	59	45	343	166	48%	Bimonthly or quarterly
4—How often do you use *online tests* as a means of assessing the students?	252	20	41	14	16	343	51	15%	Never
5—How often do you use *in-person test* as a means assessing the students?	8	1	176	122	36	343	246	72%	Bimonthly or quarterly
Private school									
1—How often do you use *homework assignments* as a means of assessing the students?	19	5	28	50	18	120	82	68%	Monthly
2—How often do you use *exercise lists* as a means of assessing the students?	8	1	11	15	85	120	106	88%	Weekly
3—How often do you use *oral presentations* as a means of assessing the students?	36	10	35	26	13	120	57	47%	Bimonthly or quarterly
4—How often do you use *online tests* as a means of assessing the students?	84	9	15	10	2	120	20	16%	Never
5—How often do you use *in-person test* as a means of assessing the students?	3	0	49	55	13	120	93	77%	Monthly

The data were obtained from an opinion survey in which the semantic differential followed the Likert-type scale in the format of 5 points. The sample of respondents was composed of 74% from public school teachers and 26% from private school teachers. In the table data for the total number of respondents (TR), proposition agreement (PA), and proposition agreement degree (PAD) are also included.
1—Never, 2—Annually, 3—Bimonthly or quarterly, 4—Monthly, and 5—Weekly.

items, similar statistical analyses were conducted, as indicated in Table 1.

3 Results and discussions

We will now analyze the results obtained from the questionnaire applied to teachers. First, we will examine the assessment methods they use and their frequency. Then, we will assess the impact of ChatGPT on student education quality, as well as teachers' opinions on whether its use constitutes plagiarism or a similar infraction. Furthermore, it is important to highlight that although the sample has more than 400 respondents, the generalization of results based on this number of participants must be analyzed with caution and interpreted as preliminary results. However, it has the potential as an initial working hypothesis for larger studies with more representative samples.

3.1 The assessment methods used by teachers and their frequency

Table 2 shows the teachers' responses on the frequency of using written assignments, exercise lists, oral presentations, online tests, and in-person tests as student assessment methods. As can be seen in this table, in both public and private schools, the use of exercise lists is the assessment method most used by teachers (weekly), followed by

TABLE 3 Propositions agreement degree analysis related to the number of responses provided by the teachers in response to questions about the impact of ChatGPT on the quality of student education and assessment methods, and whether teachers believe that the use of ChatGPT constitutes plagiarism or a similar infraction.

	Semantic differential								
Statements	1	2	3	4	5	TR	PA	PAD	Interpretation
Public school									
1—ChatGPT will affect the quality of students' education	13	49	24	145	76	307	233	76%	Partially agree
2—ChatGPT will enhance the quality of students' education	30	100	41	109	24	304	154	50%	Neutral
3—ChatGPT will affect the assessment methods	35	68	35	101	69	308	188	61%	Partially disagree
4—ChatGPT use is a plagiarism or a similar infraction	59	66	60	80	44	309	154	50%	Neutral
Private school									
1—ChatGPT will affect the quality of students' education	3	17	5	51	36	112	90	80%	Partially agree
2—ChatGPT will enhance the quality of students' education	11	37	13	44	4	109	55	50%	Neutral
3—ChatGPT will affect the assessment methods	8	28	11	29	36	112	71	63%	Partially disagree
4—ChatGPT use is a plagiarism or a similar infraction	16	25	20	34	18	113	62	55%	Neutral

The data were obtained from an opinion survey in which the semantic differential followed the Likert-type scale in the format of 5 points. The sample of respondents was composed of 73% from public school teachers and 27% from private school teachers. In the table data for the total number of respondents (TR), proposition agreement (PA), and proposition agreement degree (PAD) are also included. 1—Completely agree, 2—Partially agree, 3—Neutral, 4—Partially disagree, 5—Completely disagree.

homework assignments (monthly), and oral presentations (bimonthly or quarterly). In addition, very few of them use online tests as an assessment method. This result suggests that in Brazil, for K-12 science teachers, exercise lists stand out as one of the main ways of practicing the content studied, while homework assessments (which help develop study, research habits, and intellectual discipline) come second. However, despite the well-known importance of oral presentation assessment (that leads to the students a deeper reflection on a given topic and problem) K-12 science teachers in Brazil seem to let this type of assessment in the background.

On the other hand, it draws attention to the fact that teachers, both in public and private schools, never use online tests as an assessment method. Although K-12 science teachers in Brazil had to adapt themselves to its use during the COVID-19 pandemic, the results indicate that currently, more than 70% of them seem to have abandoned this approach. Our interpretation is that the school culture contributes significantly to teachers resisting the use of online assessments as much as possible (AL-Takhayneh et al., 2022), even though it can be argued that online tests can be as effective as in-person tests for measuring course proficiency (Fisher et al., 2022).

Regarding the in-person test, the results indicated a slight difference in the frequency with which these tests are applied in public (bimonthly or quarterly) and private (monthly) schools. This is probably related to the fact that Brazilian schools divide the school year into four bimesters. In this situation, private schools generally demand at least two tests for each bimester, while public schools generally demand only one. There is practically a consensus among educators on the importance of assessment tests to identify how well the student understood the content studied. However, despite this, our results indicate that almost 86% of Brazilian K-12 science teachers, who work in public schools, only apply the minimum number of tests currently required. This conduct goes against the trend advocated in several studies related to the importance of the use of formative assessments (Boström and Palm, 2023). Maybe this is due to the low weekly workload that science subjects have had in Brazil in the last few years (Moreira, 2018).

3.2 The impact of ChatGPT on the quality of student education and assessment methods

Another investigation carried out in this study involved collecting teachers' opinions about the impact of ChatGPT on the quality of student education and assessment methods, as shown in Table 3. Based on these results, it is evident that teachers have mixed opinions about the impact of ChatGPT on the quality of students' education.

Furthermore, teachers' opinions about whether ChatGPT will enhance the quality of students' education are also divided. Approximately half of them believe that ChatGPT will improve students' education, while the other half think that it will not. This shows that most teachers are skeptical about the potential improvements in education that can occur using this type of generative AI. Probably because they are unaware of the great potential of this type of technology, as reflecting the opacity of AI generative models (Laupichler et al., 2022).

Generative AI holds the potential to greatly benefit teachers by assisting them in various ways, including the creation of educational materials such as lesson plans, worksheets, and custom textbooks. It can also assist students by generating personalized quizzes, assignments, and study recommendations based on their strengths and weaknesses, thereby improving the effectiveness and personalization of learning. Additionally, students are leveraging ChatGPT to swiftly access answers, clarify complex concepts, and explore scientific topics beyond the standard curriculum. Furthermore, Ouyang et al. (2022) suggested that AI can provide immersive learning experiences through virtual reality technology. In addition, it is important to emphasize that the use of AI tools can significantly enhance the teaching-learning process in Professional Education, including fields such as Engineering (Johri, 2020; Qadir, 2023), Medicine (Feng and Shen, 2023; Lee, 2023), and Architecture (Ceylan, 2021; Zhang et al., 2023). This underscores the importance and potential of the theme. However, it is human nature to reject what we do not understand, especially when the unknown can affect others besides ourselves, in this case, students (Gómez Crespo et al., 2014; Ventouris et al., 2021).

Considering Brazil's cultural, social, and economic heterogeneity, we understand that these results, although preliminary, point to the urgent need for continued training for in-service teachers. This training should encompass elements of didactic methodology, assessment, and the use of new technologies, particularly those based on generative AIs. Although this type of training already exists in Brazil, as exemplified by programs such as the Mestrado Nacional Profissional em Ensino de Física and similar initiatives (Moreira et al., 2016; Ferreira et al., 2021; De Paulo and Moreira, 2022; MNPEF, 2023), efforts like these must not only be sustained but also improve. This is crucial to address teachers' challenges in adapting to changes imposed by technological advances.

In the questionnaire, teachers were also asked their opinions on whether ChatGPT will affect assessment methods. The results in Table 3 showed that, in both public and private schools, most teachers have some reservations about this statement. In their opinion, assessment methods will not be significantly affected. As mentioned in the previous paragraph, generative AI tools will significantly expedite the creation of in-person tests for teachers. However, with homework assessments, such as reports, teachers will need strategies to verify whether students wrote the work themselves or used generative AI to complete it. This issue will be further discussed in the next paragraph. In summary, it is crucial that, despite these challenges, teachers remain open to the potential for developing creative methodologies with the use of ChatGPT (Yu and Guo, 2023).

Another problem is whether the use of ChatGPT by students will reduce their interest in doing research in books and even on the internet since ChatGPT produces responses that closely resemble content from online sources or textbooks. In such cases, students might submit this work as their own without conducting any research or putting in any effort. In addition, it can discourage them from seeking information from a variety of sources and developing their research and critical skills. In that case, the overconfidence of the students using generative AI can lead them to a condition of being a mere spectator, harming interactive learning. Something like this can compromise personal expression and the ability to develop logical thinking, as well as creativity. Other drawbacks of ChatGPT use in schooling include the potential for fostering an overreliance on technology among students and promoting reduced social interaction among them. In light of these trends, educators must recognize and address the potential negative effects. Developing strategies to promote critical thinking, provide personalized feedback, and encourage hands-on learning experiences becomes crucial in mitigating the challenges posed by increased reliance on tools like ChatGPT.

While technologies like ChatGPT are gradually being incorporated into education, teachers must not forget that traditional methods, such as oral presentations, viva-voce examinations, practical training, and hands-on workshops, offer unique benefits. These methods foster essential skills such as public speaking, critical thinking, problem-solving, and the practical application of knowledge. They provide opportunities for real-time interaction, feedback, and experiential learning that technology cannot fully replicate. For example, Delson et al. (2022) discussed the impact of oral exams on student performance and motivation. One of the results they obtained showed that the group with the instructor increased their grade by 14%. Additionally, approximately 70% of the students who participated in the research strongly agreed or agreed that the oral exams increased their motivation to learn. Therefore, by incorporating these traditional methods into education, students develop a well-rounded skill set that prepares them for real-world challenges. While technology has its advantages, the value of in-person communication and practical experience cannot be overstated.

A worrying issue is also related to using ChatGPT as a reference tool for students during exams. How can teachers ensure that students utilize it as a "tutor" rather than simply copying the entire answer provided by ChatGPT? This appears to be a difficult issue to address. Furthermore, teachers must help their students understand that generative AI, such as ChatGPT, can generate stereotypical responses based on the training data they receive. For instance, if it is trained on a dataset with biased or racist content, its generated responses may reflect those biases unless mitigated by careful training practices.

3.3 Is the use of ChatGPT considered plagiarism or a similar infraction?

With the launch of generative AIs accessible to the public, such as GPT-3 (a previous version of the ChatGPT model introduced by OpenAI in June 2020), access to this type of technology has grown exponentially. Thus, the public has access to a technology previously present in only a few sectors of society. ChatGPT was launched very recently, in November last year. In that case, many discussions regarding the ethics of the use of this AI need to be conducted, particularly in education (Dempere et al., 2023). What may be considered an ethical violation or plagiarism for some people will not be considered an ethical violation for others. Some teachers may argue that students will end up using it to obtain undue advantages, expressing knowledge or skills that they

do not possess. On the other hand, other teachers may argue that ChatGPT can be an effective "tutor" for their students.

The results of the teachers' opinions on that question, whether ChatGPT use is plagiarism or a similar infraction, are also shown in Table 3. The opinion of teachers is quite divided; practically half consider the use of ChatGPT to be plagiarism or a similar infraction, and the other part of teachers think it is not. Particularly, teachers' concern about the authorship of work done by their students was already present during the COVID-19 pandemic (Muassomah et al., 2022), when classes were held exclusively online for several months and students completed virtually all assessments at home, remotely. Currently, the literature already presents examples of institutions that banned ChatGPT or updated their definitions of plagiarism about its use (Cassidy, 2023; Soper, 2023).

In our opinion, generative tools, like ChatGPT, differ from plagiarism because they create "new text" rather than simply copying and pasting. The question then arises: Who is the true author of the work, the student or ChatGPT? The interaction with ChatGPT involves creating prompts, but does that alone make the user the primary author?

In our view, the novelty of this technology leaves many questions unanswered. A similar conundrum arises when using generative AI to create images. Tools like Canva, DALL-E, and Adobe Firefly raise questions about authorship. Is the AI or the person who provided the prompt considered the image's creator? Furthermore, can such an image be deemed copyrighted? These remain open questions without a clear consensus.

The widespread availability of generative AI tools, particularly among teachers and students, has sparked inquiries that require deliberation within the educational community and society as a whole. Like the emergence of the internet and the subsequent concerns about massive data storage by companies for personalized advertisements, the use of generative AIs prompts questions about ethical boundaries and potential infractions. In the past, regulations were scarce in this regard, but with the evolution of technology, strict laws now govern how companies handle and share customer data.

We anticipate a similar trajectory for generative AIs, with the establishment of regulations in the coming years. This regulatory framework will provide clearer guidelines, helping to define ethical boundaries and delineate when the use of these tools may cross into unethical or infringing territory.

Finally, teachers can check text similarity and identify the source of original content using various online plagiarism detection tools. Some popular plagiarism detection tools include Turnitin, Grammarly, Copyscape, and Plagscan. Furthermore, teachers can also check if a text was generated by a generative AI using specialized AI detection tools designed to identify machine-generated content. Additionally, teachers can look for common indicators of AI-generated text, such as unusual word choices or combinations that are not typical of human writing, incoherent or nonsensical sentences lacking logical flow, a lack of personal voice or individual writing style, and an overuse of repetitive phrases or patterns. While it can be challenging to detect AI-generated text, especially as AI models become more advanced, these methods can help teachers identify content that may have been generated by a machine rather than a human author. In addition to using these tools, teachers can also manually check for text similarity by conducting internet searches or using search engines to find the original source of the content. They can also ask students to provide citations and references for their work to verify the originality of the content.

Although some developers are trying to create tools to find out if a text was done by generative AI and to inhibit its indiscriminate use (Gao et al., 2022; Chaka, 2023; Originality, 2023), perhaps the problem is deeper and involves a broad discussion of what plagiarism essentially is or is not (Khalil and Er, 2023; King and ChatGPT, 2023; Kleebayoon and Wiwanitkit, 2023), as discussed before. Furthermore, considering the inevitable integration of AI with various domains, as advocated by numerous authors (Kelly, 2016; Daugeliene and Levinskiene, 2022), it appears both urgent and unavoidable to engage in discussions about regulatory and ethical limits for the use of AI technology within an international framework (Sethu, 2019; Tong et al., 2022). Furthermore, to discourage students from resorting to cheating with AI tools, some authors propose the establishment of a "new educational pact" with the active participation of students. This approach encourages students to reflect on their roles in learning and society (Fyfe, 2023; Sadeghinejad and Najmaei, 2023; Sullivan et al., 2023). However, there is still no consensus on the feasibility of implementing this "new educational pact."

4 Conclusion

The study explored the perspectives of K-12 science teachers in Brazil, investigating various aspects, including the types and frequency of assessment methods used with their students. Additionally, the research delved into their opinions on whether ChatGPT would impact the quality of education and assessment methods, as well as their views on whether ChatGPT should be deemed plagiarism or a similar infraction.

The findings reveal that in both public and private schools, teachers predominantly employ exercise lists as the primary assessment method, followed by homework assignments and oral presentations. Notably, a minimal number of educators incorporate online tests into their assessment practices. The analysis of in-person tests indicates a subtle disparity in their frequency, with public schools conducting them bimonthly or quarterly, and private schools opting for a monthly schedule. A noteworthy observation is that around half of the surveyed teachers believe that ChatGPT will enhance students' education, while an equal proportion (approximately) holds a contrary view. In addition, there is a consensus among them that assessment methods are unlikely to undergo significant changes with the integration of ChatGPT.

We also discussed the issue concerning students' use of ChatGPT and its potential impact on their inclination to engage in traditional research methods, such as exploring books and online resources. The concern arises from ChatGPT's capacity to generate responses closely mirroring content found in online sources or textbooks. In these instances, there is a risk that students may present this content as their own without undertaking genuine research or exerting effort.

Concerning the plagiarism implications associated with ChatGPT use, there is a notable division of opinion among teachers. Approximately half of them view the utilization of ChatGPT as constituting plagiarism or a similar infraction, while the other half disagree. This divergence underscores the need for discussion within the educational community and society at large, given the widespread accessibility of generative AI tools to both teachers and students. From

our perspective, this issue prompts a broader conversation about plagiarism's fundamental definition and boundaries in association with the use of generative AIs.

In conclusion, we hope that the results presented here, along with the accompanying discussions, will aid educators in reflecting on the implications of ChatGPT in education. Specifically, in our opinion, this work contributes to the ongoing dialogue about establishing clear standards. These standards would delineate when the use of ChatGPT by students is considered positive and provide well-defined rules to distinguish instances that may constitute plagiarism or a similar infraction.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

FM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. PS: Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. MS: Conceptualization, Writing – review & editing. JM: Conceptualization, Investigation, Writing – review & editing. WS: Writing – review & editing. DG: Conceptualization, Data curation, Writing – review & editing.

Funding

The author(s) declare financial support was received for the research, authorship, and/or publication of this article. FM acknowledges the financial support from a DPI/DPG/BCE 01/2024 grant 23106.012579/2024-56.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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