Integration of ChatGPT in 5E inquiry model and its impact in learning biology

Zeina Haddad

Iman Abou Ali

Lebanese University- Doctoral School of Literature, Humanities, & Social Sciences – Beirut, Lebanon

zeinaahaddad@gmail.com

imane.abuali@gmail.com

Abstract

The past few years witnessed the emergence of artificial intelligence which firmly affected the educational field, through ChatGPT, a chatbot that can create data in a human-like interaction (Francesc et al, 2019). Although ChatGPT was found to be a valuable asset in the learning-teaching process, some questions keep arising about its actual impact and challenges (Lo, 2023). In this research, we'll try to answer the following questions: How does ChatGPT in a 5E inquiry model lesson impact motivation and grades of students in a biology lesson? What do teachers and students think about the integration of this chatbot in their education process? The aim of this study is to unfold the level of efficiency of ChatGPT in teaching and learning that goes hand in hand with better grades and motivation of students. It also aims at identifying the ethical whereabouts of AI in schools. Two grade twelve classes will be taught about hormonal transmission in a 5 E inquiry setting. An experimental class of 29 students used ChatGPT and a control class of 27 students didn't utilize it. An oral interview with the teacher as well as an observation grid, a questionnaire, and a test to compare grades of the two classes for students, were used to collect data. The results showed that ChatGPT enhanced grades and motivation in class. The majority of students and the teacher think that ChatGPT is a great tool that eases the learning process but needs some training and guidance to be used fairly and ethically.

Key-words

Résumé

Les dernières années ont témoigné à l'émergence de l'intelligence artificielle, qui a influencé le domaine éducationnel, à travers ChatGPT, un assistant virtuel capable de créer des interactions humaines. (Francesc, Subosa, Rivas, & Valverde, 2019). Bien que ChatGPT s'est montré comme atout de valeur en éducation, quelques questions se manifestent sur son usage. (Lo, 2023) Dans cette étude, nous tenterons de répondre aux questions suivantes : Comment le ChatGPT impacte-t-il la motivation et le score des élèves sujet à une leçon de biologie basée sur l'enquête 5E ? Que pensent les élèves et l'enseignante au sujet de l'intégration du ChatGPT` au sein du processus éducationnel ? L'objectif de cette recherche est de révéler le niveau d'efficacité du ChatGPT en classe, et son influence sur de meilleurs scores et une motivation plus élevée. L'étude vise également à identifier les implications éthiques de l'IA au niveau des institutions scolaires. Deux classes de terminal apprendront une leçon sur la transmission hormonale, basée sur l'enquête 5E. Une classe expérimentale de 29 élèves utilisera le ChatGPT et une classe contrôle de 27 élèves n'en fera pas usage. Un questionnaire, une entrevue avec l'enseignante, une grille d'observation et une évaluation sont les outils de collecte de données. Les résultats dévoilent que ChatGPT améliore la note et la motivation en classe. La majorité des élèves et l'enseignante pensent que le ChatGPT facilite le processus d'apprentissage mais demande des stages et des formations pour que son usage soit juste et éthique.

Mots-clés

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مستخلص

في السنَوّاتِ الأخيرَة، شَهِدنا ظُهورَ الذَكَاء الاصطِناعي، الذي أَثَر بشكلٍ قوي على مجالِ التعليم، خاصّةً من خِلالChatGPT ، المساعِد الافتِراضي القادِر على

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إنشاء تفاعِلات شبه بشريّة (Francesc, et al, 2019). على الرغم مِن أنّ ChatGPTظَهَر كمورِد قيم في التعليم، إلا أن بَعض الأسئِلَة تطرح حَوْل استخدامه (Lo, 2023). في هذه الدراسة، سَنُحاول الإجابَة عن الأسئِلَة التالِيَة: كيف يُؤثِر ChatGPT على الدافِعيّة ودرجات الطُلاب اللذِين يتَلقَون درسًا في علم الأحياء، يستند على استقصاء E5؟ ما رأي الطُلاب والمُعلِمة فيما يتعلق بتكامُل ChatGPT في العمليّة التعليميّة؟ فإن هَدَف هذه البحث إذاً، هو كشفُ مُستوى فعاليّة ChatGPT في الصفّ وتأثيره على تحسين الدرجات وزيادة الدافِعيّة. كما تهدِف الدراسة أيضًا إلى تحديد الآثار الأخلاقيّة للذكاء الاصطِناعي على مستوى المؤسسات التعليميّة. سَتتلقَى مجموعَتان درسًا عن الانتقال الهُرموني، استِناذًا إلى استقصاء E5، مُقسّمة إلى مجموعة ضابطة ومجموعة تجريبيّة. سَتستخدِم المجموعة التجريبيّة المُؤلفة مِن ٢٩ تلميذًا، الـ ChatGPT خلال الدرس فيما لن يتم استخدامه في المجموعة الضابطة المُؤلفة مِن ٢٧ تلميذًا. إنّ مُقابلة مع المُعلِمة، وشبكة ملاحظة، وتقييم لمقارنة المتوسط المدرسي للمجموعتين هي الأدوات المستخدمة لجمع البيانات. تكشِف النتائِج أن ChatGPT يُحسّن الدرجات والدافِعيّة في الصفّ. كما أنّ مُعظم الطُلاب والمُعلِمة يعتقدون أنّ ChatGPT هو أداة فعّالة تسهل عمليّة التعلّم، ولكنها تتطلب تدريبات لاستخدامه بشكلٍ عادل وأخلاقي.

كلمات مفتاحية

الذكاء الاصطناعي، ChatGPT، التحفيز، الدرجات، الأخلاق

1. Introduction

The past few years have witnessed the emergence of a worldwide phenomenon: artificial intelligence (AI). It took over all domains, ultimately impacting the educational field (Francesc,et

al , 2019). The definition of AI has changed drastically since the term first appeared in 1956 with the evolution of machinery (Collins,et al , 2021). It was known as a "*somewhat broad church where many forms of automation and limited intelligent machines are labelled as AI*" (Dwivedi, et al., 2021). At first, it was limited to computers but nowadays, AI shifted to intelligent chatbots capable of performing instructional tasks through human interactions (Chen, Chen, & Lin, 2020). They have opened the horizon to new methodologies of work in the educational learning process. One of them being ChatGPT, it showed its ability to simulate a human conversation with its users, using a large database of texts, information, and algorithms. It can answer any question it is asked, acts as an instructor, and helps understand complex concepts (Klayklung, et al, 2023).

It can benefit teachers by personalizing lesson plans, highlighting new ideas for their classes, and enlarging their literacy opportunities. As for students, ChatGPT can help them understand complex notions and concepts and enlarge their knowledge through self-teaching, an important skill in the 21st century. (Su & Yang, 2023)

Although ChatGPT was found to be a valuable asset for students and teachers in the learning-teaching process, some challenges remain. Various questions keep arising about its use, ethics, and actual impact on the educational process. (Nayir, et al, 2024)

In this research, we'll try to determine how the integration of ChatGPT in a 5E inquiry-based setting impacts students and teachers in a biology lesson, to answer the following questions:

- How does ChatGPT in a 5E inquiry-based setting impact motivation of students in a biology lesson?
- How are grades of the students affected by the ChatGPT implementation in a 5E inquiry-based biology lesson?
- What do teachers and students think about the integration of ChatGPT in their education?
- What are the ethical implications of ChatGPT in education?

The aim of this study is to unfold if ChatGPT is an efficient approach of teaching and learning in a 5E inquiry lesson, which improves grades and motivation of students. It also strives to identify the ethical implications of AI in schools. Furthermore, it sets sights on highlighting the importance of ChatGPT in the minimization of efforts and time consumption in the teaching process.

We believe results will show, at the end of this research, that ChatGPT enhances motivation and grades of learners. The majority of students and the teacher will think that ChatGPT facilitates the learning process, but some training should be available to use AI ethically.

1.1. Literature review and theoretical background.

1.1.1 Concept of AI

To this day, no official definition of "artificial intelligence" exists (Martinez, 2019). Since the term was first officialized by John McCarthy in 1956, a myriad of definitions was written. McCarthy himself defined it as *"the science and engineering of making intelligent machines"* (Manning, 2020). A newer definition by Russell & Norvig (2021) perceives AI as "a field within computer science specialized in building systems that mimic human cognitive abilities and intelligence such as perception, decision-making, language, and speech recognition." AI is defined by a number of objectives; thus, managed through several approaches such as, "artificial neural networks," "deep learning" and "GPT" (Toosi, et al., 2021; Haenlein & Kaplan, 2019). While machine learning uses algorithms that study individual patterns to advance without needing to be programmed (Sarker, 2021), artificial neural networks transmits data through processors similar to neurons in the brains, each equipped with a memory with inputs and outputs (Kumar, et al., 2012). As for deep learning, it operates on several neuron-like entities to transmit data in multiple layers between inputs and outputs (Deng & Yu, 2014). These approaches constitute the functioning bases of ChatGPT (Mohd, et al., 2023).

1.1.2. ChatGPT

GPT or "Generative Pre-trained Transformers" are deep learning-based chatbots that use transformer architecture, inspired by neural networks to generate natural language processing to communicate with the users (Shen, et al., 2023).

Since 2022, ChatGPT has been the newest trend in the AI world (Rudolph, et al., 2023). It was created by OpenAI and uses large language models, an extrapolation of machine learning and deep learning approaches (Mohd, et al., 2023), to make the desired conversation with its handlers, as it

operates through supervised learning and reinforcement learning from human feedback (OpenAI, 2022; Cheng, et al., 2023). Since it holds a huge amount of data and can auto-interact with users, it can also remember the past conversation and pick it up from where it previously ended, making the dialog unique to each individual (Farrokhnia, et al., 2024). Defined as one of the most powerful AI communicative tools, ChatGPT paved its way across many sectors, including education (Cao, et al., 2018).

1.1.3. ChatGPT and education

1.1.3.1. 5E Inquiry-based lesson learning

Science teaching in a classroom entails motivating learners and igniting their curiosity. Therefore, teachers use the inquiry approach in their lesson planning that incites them to explore, question their surroundings and use evidence to explain their findings. (Gerges, 2022)

A useful approach to inquiry-based learning is the 5E learning cycle. Roger Bybee set up an educational design made by a cycle of five phases known as the 5 E's: engagement, exploration, explanation, elaboration, and evaluation (Bybee, et al., 2006). This sequence gives teachers a structural design to help students achieve the educational goals of the lesson by connecting ideas and experiences in a conceptual manner (Duran & Duran, 2004).

Recent research shows that this method of teaching is very effective in improving quality of learning and performance of students (Yonyubon, et al., 2022; Ong, et al., 2018), the understanding of the subject (Malone, 2023) and critical thinking and scientific reasoning (Cahyarini, et al., 2016). Due to its proven benefits, this instructional design was chosen to be the teaching method in our study.

1.1.3.2. ChatGPT and 5E inquiry-based learning

ChatGPT is bringing radical modifications within the scholastic scenery. It can interact with students by answering their questions on any subject, give them an adaptive learning context through individualized explanations, feedback, and virtual replications of scientific concepts (Zhu, et al., 2023; Kılınç, 2023). Consequently, ChatGPT encourages critical thinking and scientific reasoning through brainstorming and discussions that influence the students to ponder upon hard

scientific concepts. This is proven by studies done by Božić & Poola (2023) and Goodman, et al, (2024) which aligns with the 5E inquiry-based learning teaching method.

Other studies disclosed that ChatGPT's integration in a 5E inquiry-based lesson enhanced the students' science learning achievement and performance (Kulapian & Chittranun, 2023), as well as the motivation and performace of students (Kılınç, 2023).

1.1.3.3. ChatGPT and teachers

ChatGPT can be a very powerful implement in the hands of teachers as it helps them reduce time and effort given to lesson planning (Karakose & Tülübas, 2023). Once asked and guided through the steps by the teachers, ChatGPT can formulate a well-made science lesson (Luo, et al., 2024).

Some studies show that ChatGPT endorses teachers with an extensive assortment of activities, resources, and ideas convenient to the time and goals of the lesson (Karakose, et al., 2023; 2023; Mondal, et al., 2023).

Overall, there are a number of ongoing research efforts exploring the potential applications of large language models in the educational area. (Čavojský, et al., 2023)

1.1.4. Ethics of ChatGPT

ChatGPT represents a huge number of benefits and limitations. Cheating and plagiarism are main concerns with ChatGPT, since it is capable of authoring complete essays instead of the students, making complete projects and writing PhD theses and dissertations, leading to loss of credibility (You, 2024; Lo, 2023). According to Fyfe (2023), students thought that ChatGPT2.0 generated short, patterned essays and didn't always cater for what they wanted. As for Khalil & Er (2023), they experimented with plagiarism detection tools and found that 40 out of 50 essays were not detected and displayed a high level of exclusivity.

On the whole, ChatGPT constitutes a double-sided sword, with various benefits as well as challenges, which should be balanced for optimal efficiency.

2. Methodology

2.1. Research design.

This research is an experimental comparative design, in which the population is divided into two groups: the control group and the experimental group. The goal is to explain what ChatGPT brings to the table that a traditional lesson does not by comparison.

2.2. Participants

The sample consists of 56 students in grade twelve who are taught about hormonal transmission in a 5E inquiry-based lesson setting. The sample will be divided into two groups, both taught by the same teacher. One class consists of 27 students representing the control group, whereas the experimental group consists of 29 students.

2.3. Instruments

Data is collected through four instruments: an observation grid, a questionnaire, an oral interview, and a test.

The observation grid consists of 9 items about students' motivation and engagement during the lesson.

The questionnaire consists of 14 items, categorized each according to one of the axes of analysis concerning use of ChatGPT, personalized learning, motivation, skills and grades, ethics, and prospects of ChatGPT and overall experience. The questionnaire's reliability is measured with Cronbach's alpha, which is valued as 0.952, indicative of a high internal consistency.

An oral interview is conducted with the teacher where she is asked 19 questions that correspond to the five axes of analysis mentioned above.

The test is administered to both classes and contains two analytical exercises regarding hormonal transmission.

The interview with the teacher as well as the observation grid and the student's questionnaire were all piloted on a random sample of 25 students, similar to the sample of choice of the present study.

Table 1: Observation Grid of motivation and engagement of students in class

	Without ChatGPT integration	With ChatGPT integration
Attention span: Are students well focused on the events of the lesson?		
Participation: How much do students participate in class within the session?		
Interaction: Do students interact with the teacher and with each other by asking questions about the lesson and discussing their findings?		

Table 2: Questionnaire on ChatGPT in 5E inquiry-based model lesson

Questionnaire: ChatGPT in 5E Inquiry Model Biology Lesson

Instructions: Please answer the following questions by selecting the most appropriate options.

1- Did you use ChatGPT prior to this lesson?
- Yes
- No

2- How comfortable do you think you are with using technology, specifically ChatGPT, in your learning of biology concepts?
- Very comfortable
- Somewhat comfortable
- Neutral
- Not very comfortable
- Not at all comfortable

3- Do you believe that integrating ChatGPT in the biology lesson helped you in understanding the subject matter better?
- Yes
- No

Table 3: preview of the questions of the oral interview with the teacher

1- For how long have you been teaching biology?

2- How long have you taught grade 12? Have you taught any other classes?

3- Can you briefly describe your experience and background in teaching biology?

4- When was the first time you heard about AI? And ChatGPT?

5- Why did you decide to integrate it in your teaching tools? Is there any specific characteristics that rose your interest in using ChatGPT?

6- In which manner were you able to add ChatGPT in your lesson plans and introduce it smoothly and easily to your students?

7- Was there any need to adjust your students to this new tool? Any training or preparation involved?

8- Do you think that specialized training and workshops are required for teachers and students to effectively operate AI in education?

9- What was the most notable thing that changed during class with the interaction with your students?

10- Did their engagement and motivation as well as participation in discussions change during class after integrating ChatGPT?

11- From your point of view, does ChatGPT contribute to a better understanding and assimilation of complex biology concepts?

12- Can you name one instance where ChatGPT significantly impacted a student's learning

2.4. Data Collection

First, two 5E inquiry-based lesson plans on the hormonal transmission are prepared by ChatGPT and altered by the teacher, for optimum effectiveness. One lesson plan incorporates ChatGPT as a way to transmit key concepts and is taught to the experimental group. In contrast, the second lesson is planned with no AI implementation and taught to the control group.

After the lessons are completed, at the end, the same test is administered to both groups, in order to compare the mean average of the score results.

While both lessons are taught, the researcher fills the motivation observation grid. Afterwords, the questionnaire is distributed to all students of the experimental group, followed by an interview with the teacher, to gather more data on their opinions on the use of ChatGPT within the biology lesson, and the ethical implications they think matter in this subject.

The whole experiment was completed during November of 2023-2024. The anonymity of the students and teacher's identity is guaranteed.

2.5. Data analysis

The questionnaire is studied through statistical descriptive analysis, using Statistical Package for the Social Sciences (IBM SPSS 25.0), according to the previously mentioned axes of analysis.

3. Results

Our study is based on five axes of analysis according to which our results are defined.

In the axis of analysis concerning the use of ChatGPT, the questionnaire findings show that 75.9% of the sample had prior use of ChatGPT. Most of the students were very comfortable (37.9%) using ChatGPT, while 6.9% were not comfortable at all.

Table 4: Table showing the percentage average for each answer of question number 2.

2-How comfortable do you think you are with using technology, specifically ChatGPT, in your learning of biology concepts?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	very comfortable	11	37.9	37.9	37.9
	Somewhat Comfortable	10	34.5	34.5	72.4
	Neutral	2	6.9	6.9	79.3
	Not very comfortable	4	13.8	13.8	93.1
	Not comfortable at all	2	6.9	6.9	100.0
	Total	29	100.0	100.0	

Most of the students understood the answers given by ChatGPT (93.1%). However, almost half of students (44.8%) found it hard to get the answers correctly while using it in the assignment they were given after the lesson.

On the other hand, the teacher in her interview, acknowledges that a proficient incorporation of ChatGPT within her biology class required time so that both her and her students got used to it and knew how to use it appropriately.

In the axis of analysis concerning personalized learning, through the questionnaire results, it is revealed that the majority of students found the incorporation of ChatGPT in the lesson helpful. 79.3% think ChatGPT helped them understand notions better and 82.8% of students found it helpful to process key concepts of the lesson. 37.9% thought that ChatGPT was very effective in exploring the lesson content and 69% estimated that ChatGPT improved their knowledge on the biology topic.

Table 5: table showing the percentage average for each answer on question 4.

4-How effectively do you think ChatGPT helped in exploring the new content of the biology lesson?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	very effective	11	37.9	37.9	37.9
	Somewhat effective	12	41.4	41.4	79.3
	Neutral	4	13.8	13.8	93.1
	not very effective	2	6.9	6.9	100.0
	Total	29	100.0	100.0	

As for the interview, the teacher confirms that students were able to acquire certain concepts in biology faster and easier. However, she did face some challenges such as the resistance some students displayed towards the tool, they didn't really accept it or understand its educational purposes.

In the axis of analysis about motivation, the questionnaire shows that students are mostly motivated and engaged in the lesson with 58.6 % that found themselves very motivated. Furthermore, the observation grid compares the engagement levels in both classes and findings reveal that the integration of ChatGPT had a bigger impact on motivation of students and the classroom's ambiance in general as illustrated in the observation grid below (table 6)

As for the interview, the teacher affirms that ChatGPT did a noticeable shift in the overall atmosphere of the lesson. The students were enthusiastic, motivated and were very curious, so they kept coming up with questions for ChatGPT to comprehend major concepts better.

Table 6: Observation grid answers.

	Without ChatGPT integration	With ChatGPT integration
Attention span:	Good	Good
Participation:	Good	Excellent
Interaction:	Good	Excellent
Body language:	Fair	Good
Questioning:	Fair	Excellent
Use of technology:	Neutral	Excellent
Engagement level:	Neutral	Good
Collaboration:	Fair	Good
Motivation:	Good	Excellent

For the axis of analysis about skills and grades, findings reveal that students felt more challenged to think critically and brainstorm innovative ideas. In fact, 62.1 % of students agreed that ChatGPT increased their need to think critically.

As for the test that was taken by the control and experimental group, results show a mean average of 15.1 / 20 for the experimental class and 14.5/20 for the control class. So, this concludes that ChatGPT has a positive impact on the performance of students.

For the axis of analysis about ethical implications, 100 % of students think that ethics are to be taken into consideration especially when it comes to cheating and copying and pasting assignments and essays. 69% thought that the tendency to copy and paste from essays and assignments was strongly present.

The teacher also voiced her concern during the interview on the rising danger of plagiarism in education with the emergence of ChatGPT. She also highlights the necessity to train teachers and students on the use of ChatGPT because if not properly guided, it might become a source of distraction.

Table 7: table showing the percentage average of each answer on question number 12.
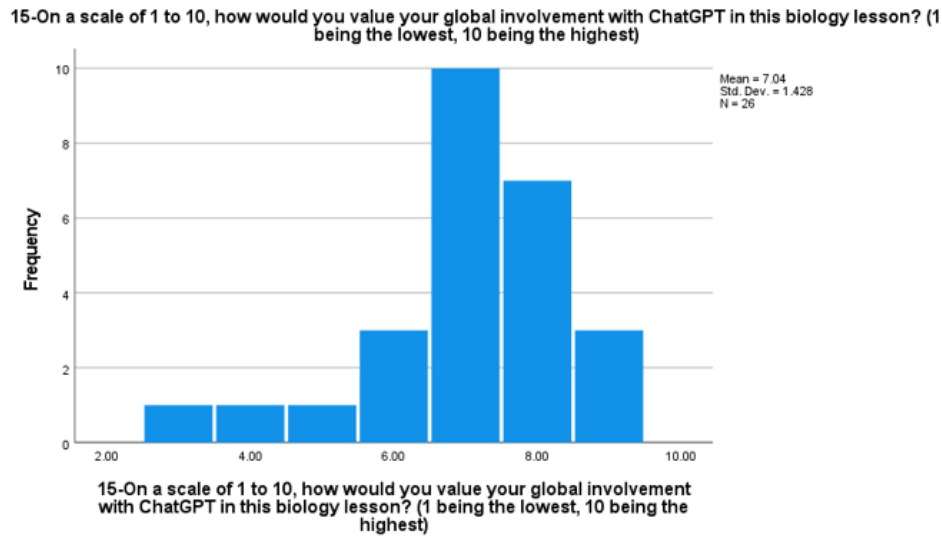
12-How likely do you think ChatGPT gives you the tendency to copy and paste the answers in your essays and assignments?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	very much likely	10	34.5	34.5	34.5
	very likely	10	34.5	34.5	69.0
	Neutral	6	20.7	20.7	89.7
	not very likely	2	6.9	6.9	96.6
	not likely at all	1	3.4	3.4	100.0
	Total	29	100.0	100.0	

For the last axis of analysis concerning the overall experience on ChatGPT and future prospects, 20.7 % thought that improving options in biology lessons for more interactivity with ChatGPT is needed, 17.2 % believed that better training on how to use ChatGPT is essential. And 44.8% considered that all options are important. And as an overall experience, on a 10-point Likert scale, with 1 being the lowest and 10 the highest, the mean average of the value of the global involvement with ChatGPT in a 5E inquiry-based lesson is 7.04. a high score for ChatGPT.

 Additionally, the teacher states that ChatGPT helped her with lesson plans, ideas, and activities for her classes as well as the reduction in time and effort put towards lesson planning and exam preparations and grading. She believes training should be provided for teachers and students through workshops, to ensure ChatGPT is managed correctly and provide awareness to students.

Figure 1: Diagram showing the average point of Likert scale determining the overall experience with ChatGPT.

15-On a scale of 1 to 10, how would you value your global involvement with ChatGPT in this biology lesson? (1 being the lowest, 10 being the highest)

4. Discussion

In the framework of the first question "How does ChatGPT in a 5E inquiry-based setting impact motivation of students in a biology lesson?", findings show that ChatGPT impacts positively motivation of students in class. Several other studies have similar findings. (Ali, Shamsan, Hezam, & Mohammed, 2023; Caratiquit & Caratiquit, 2023)

In the framework of the second question "How are grades and performance of the students affected by the ChatGPT implementation in a 5E inquiry-based biology lesson?", results reveal that student's grades are impacted positively by the incorporation of ChatGPT within the lesson. By giving personalized learning to cater the needs of each student, ChatGPT is paving the way for better understanding, thus developing the scientific knowledge and critical thinking of students, and therefore leading to better grades in tests. This was also demonstrated by other studies who researched ChatGPT as a tool for customized learning (Božić & Poola, 2023; Kılınç, 2023).

In the framework of the third question "What do teachers and students think about the integration of this chatbot in their education process?", our findings disclose that students are in favor of the incorporation of ChatGPT within their learning. Tiwari & Bhat (2023) had similar findings to the survey they had done on 375 pupils. Students also think that they should be offered more ChatGPT

training and workshops. In fact, studies show that, sometimes, erroneous information, insufficient data or unreliable resources can be given by the chatbot so it can be an obstacle for them to employ it in their learning process (Gregorcic & Pendrill, 2023).

In the framework of the fourth and final question "What are the ethical implications of ChatGPT in education?" outcomes depict the ethical implications of ChatGPT in class like plagiarism and cheating in tests, essays, and assignments by using the chatbot. Students think that the ease of use and accessibility of ChatGPT gives them more tendency to copy their assignments, feeling more prone to cheating. Khalil & Er (2023) established that the chatbot spawned essays that were unrecognizable by the detection tools, which supports students' apprehensions towards using chatbots for "*an easy shortcut to success with minimal or no effort*" (Fyfe, 2023).

5. Conclusion

In summary, ChatGPT is a revolutionary AI chatbot that presents major benefits in the educational sector if used correctly. In this research, we conclude that ChatGPT enhances motivation and engagement of students in a 5E inquiry-based biology lesson as well as their grades and some of their skills like critical thinking and reasoning. However, students and the teacher both think that ethical implications should be taken into consideration when using the chatbot since plagiarism, cheating, erroneous answers, and misuse constitute big challenges. Furthermore, workshops, policies and more training should be executed for an ethical exploitation of ChatGPT. On the whole, it is a tool that will take on every aspect of human life eventually, therefore, learning how to manage it and incorporate it in the education framework is crucial. .

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