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RESEARCH

Chatgpt vs traditional pedagogy: a comparative study in urological learning

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Abstract

Purpose Technological evolution is radically changing medical learning models. We evaluated the learning outcomes of urological concepts using ChatGPT, traditional lecture and combined approach.

Methods We conducted a randomized triple-blind study on 121 medical students with no previous formal curriculum in urology. Students were randomly divided into three study classes with different learning methods: ChatGPT, Lecture and ChatGPT + Lecture. The "adrenal glands" were randomly extracted as the subject of the lessons. Students were evaluated using a thirty-question test.

Results The evaluation test median score was higher for students who underwent ChatGPT + Lecture compared with those who had only ChatGPT (10 vs. 12, $p = 0.007$). Such differences remained statistically significant also in multivariable models adjusting according to year of course, gender and previous ChatGPT experience (estimate: 2.6, p-value = 0.002). For most of the questions (about 70%), the proportion of students correctly answering was higher in the ChatGPT + Lecture learning groups than in the other groups.

Conclusion ChatGPT loses its potential if used without a previous background. The limits of scientific reliability persist and a teacher-guided method is still essential. ChatGPT + traditional lecture gives more effective results than the single traditional lecture also allowing a better use of the chatbot.

Keywords ChatGPT · Learning methods · Medical education · Pedagogy · Urology

Introduction

Learning and teaching methods cover a lead role in medical education and define the skills of future physicians. Medical education has been traditionally based on lectures and on a teacher who provided an already organized and predefined knowledge [1]. The rising attention for learning methods is progressively leading to their redefinition passing from an associationist concept to a cognitive one [2]; in fact, in the last years many other ways have been experimented with: team-based learning [3], simulation-based learning [4], problem-based learning [5], case-based learning [6]. In these ways, students have had an active role in the surrounding reality and learning has become an active and interactive process [1].

The technological evolution of recent years has played a central role in this radical change of conventional learning models [7]. Emerging technologies, such as e-learning, mobile-learning and Artificial Intelligence (AI), have led to the rise of heutagogy. Heutagogy is an educational approach focused on self-directed learning, where students take full responsibility for their learning journey, defining their own goals and methods [8]. Recently, AI-based tools, such as Large Language Models, have been used for their potential impact on education [9].

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In this scenario, the role that ChatGPT can play in shaping medical education is highly relevant and still under evaluation [10]. Several studies have evaluated ChatGPT as a self-learning tool for medical students, primarily testing its performance on university exams or medical licensing tests [11–13].

However, none have explored its role in the teaching and learning process, either alone or combined with traditional lectures. With this in mind, we aimed to address this void by evaluating the learning outcomes of urological concepts using ChatGPT in comparison with traditional lecture and exploring the potential of combining both approaches.

Materials and methods

We conducted a prospective, single-center, randomized, triple-blind study on a total of 121 students enrolled in the 3rd and 4th year of the Medicine and Surgery course at the University "G. d'Annunzio" with no previous formal curriculum in urology.

Description of groups

The lists of enrolled students underwent a stratified randomization by year of the course to eliminate selection biases and obtain homogeneous samples. The students were divided by random assignment into 3 study classes composed as follows:

ChatGPT (*n*=41): students studied the assigned topic exclusively through questions asked by themselves to ChatGPT. They autonomously acquired knowledge through self-directed exploration for a total of 90 min.

Lecture (*n*=39): students studied the assigned topic through a 90-minute lecture using material previously prepared by the teacher.

ChatGPT+Lecture (*n*=41): students initially used ChatGPT and then revisited the same topic through a lecture for a total time of 90 min.

Every randomization was performed using Python (version 3.11.8; Python Software Foundation, available at https://www.python.org) and the Pandas library (version 2.2.1, pandas library documentation can be found at https://pandas.pydata.org). ChatGPT 3.5 was used, allowing free access for all the students across all groups without predefined prompts or guidance, to replicate a real-life self-directed learning experience. This ensured that all students had the same level of freedom in formulating their questions, maintaining consistency across groups.

Sample size Estimation

The number of students to be included within the three groups was evaluated using G*Power (version 3.1). Sample size estimation was performed a priori hypothesizing a large effect size (Cohen's effect size 0.4) with 5% acceptable alpha error and a desired power of 95%. The resulting total sample size was 102 students. Since we expected that a proportion of students might not participate in the didactic activities, even if they were registered, the total number of students that could be potentially enrolled was increased by 20%.

Topic and questions extraction

The choice of the topic was made through random draw from the book "Campbell-Walsh Urology (Twelfth Edition)" [14]. The "adrenal glands" were extracted as the subject of the lessons. The teacher, a medical doctor and associate professor of urology at our University, was informed about the topic only 2 weeks before the lesson to prepare a presentation on the subject. ChatGPT 4.0 was used by the teacher and attempted to create images and multimedia material to be used in the lecture. The specific prompt given was: *"Generate detailed and anatomically accurate illustrations for a university-level lecture on the adrenal glands, depicting their anatomy, vascularization, function, hormone-related pathologies, neoplastic diseases, and robotic adrenal surgery, following standard medical references for accuracy and clarity"*. The teacher knew nothing about the evaluation test questions. The students were blind to the topic until the beginning of the different learning modalities to avoid the acquisition of previous notions.

At the end of the learning phase, students were evaluated using a thirty-question test taken from the book "Campbell-Walsh-Wein Urology Twelfth Edition Review, third edition" [15] related to the topic (Supplementary material). Selected questions belonged to six main topics: Anatomy and Diagnostics, Physiology, Hormonal Pathologies, Neoplastic Pathologies, Surgery and Clinical Cases. Correct answers scored one, incorrect/unanswered answers scored zero marks. The test was carried out simultaneously by the 3 classes in 60 min.

Data analysis

Descriptive statistics relied on absolute and relative frequencies (%) for qualitative data and on median and interquartile ranges (IQR) for quantitative variables. Differences between groups in medians were tested by the Wilcoxon test and post-hoc analysis was conducted with the Bonferroni adjustment method; differences in proportions were tested by the Chi-square test. Linear regression models tested differences between classes in the overall cohort and within subgroups defined according to gender, year of study and previous experience with ChatGPT. (Supplementary material).

Statistical analyses were performed by a statistician blinded to the nature of the groups using R Statistical Software (version 4.0.0; R Foundation for Statistical Computing, Vienna, Austria). A p-value less than 0.05 was defined as statistically significant.

Results

Baseline characteristics

Overall, 121 students were enrolled and randomized in three classes (Fig. 1). Students median age was 23.8 years (IQR 22–25 years), mostly female 75/121 (62%), from the 3rd year course 76/121 (63%) and with no experience using ChatGPT for studying 61/121 (50%).

Effect of ChatGPT on students' evaluation test score

Median score was higher for those who underwent ChatGPT+Lecture compared to those who had only ChatGPT (10 vs. 12, p=0.007; Fig. 2a). No statistically significant differences were found according to gender (Fig. 2b), year of study (Fig. 2c) or previous experience with ChatGPT (Fig. 2d).

Univariable and multivariable linear regression models showed better performances for those undergoing ChatGPT+Lecture than ChatGPT alone. Results remained virtually the same also in subgroups defined according to gender, year of course and experience with ChatGPT (Table 1).

For most of the questions (about 70%), the proportion of students correctly answering was higher in the ChatGPT+Lecture learning groups than in the other groups (Fig. 3 and Supplementary material).

Use of ChatGPT for educational resource production

ChatGPT 4.0 was used by the teacher to make images and multimedia material for the lecture. This attempt revealed a significant lack of scientific accuracy in the images (Fig. 4), which lacked validity and contained texts with grammatical errors or nonsensical content.

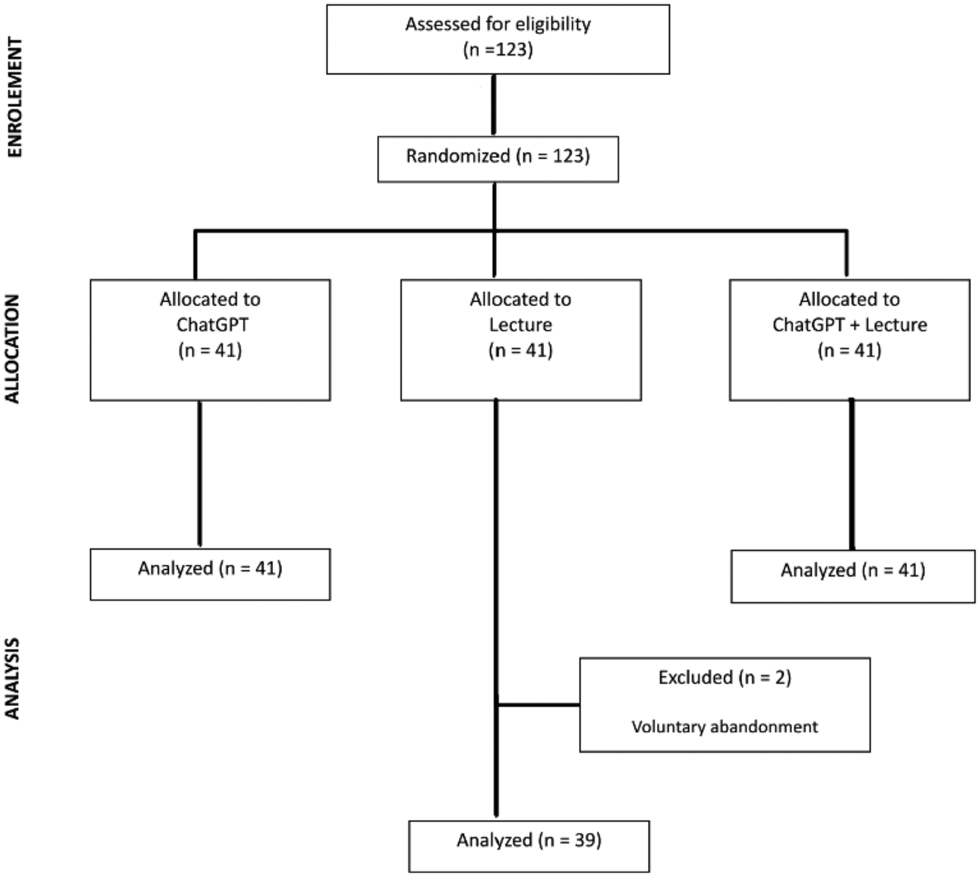


Fig. 1 CONSORT flow diagram of student enrollment, group allocation and analysis

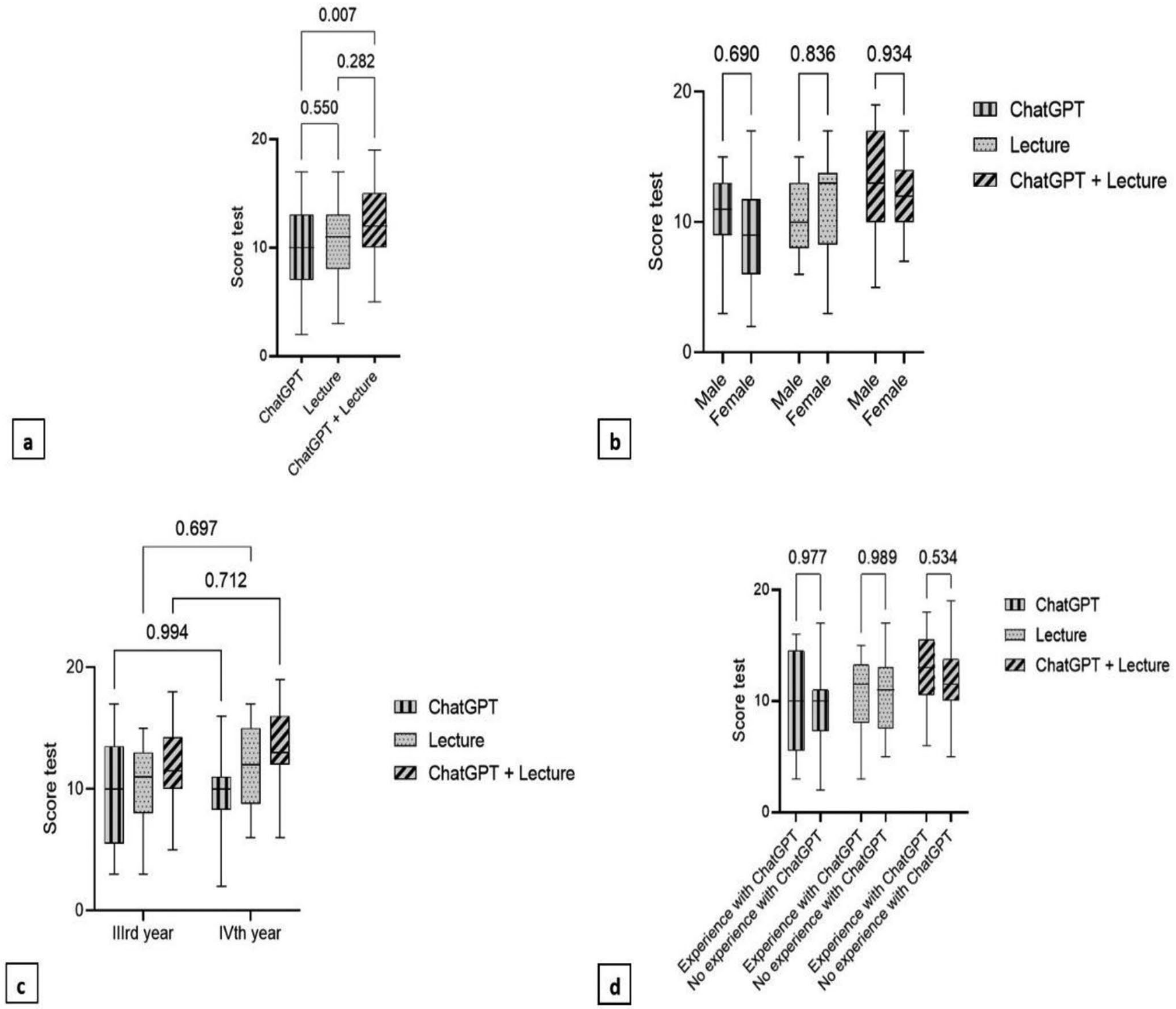


Fig. 2 Box plots showing: **a**) evaluation test median score for each class (named according to the learning method: ChatGPT, Lecture, ChatGPT + Lecture). No statistically significant differences were found according to **b**) gender, **c**) year of study or **d**) previous experience with ChatGPT. All p-values from post-hoc analyses were adjusted according to Bonferroni method

Discussion

This study analyzes learning outcomes of urological concepts using ChatGPT in comparison with traditional lecture and explores the potential of combining both approaches. Our study showed that the use of a combination of ChatGPT and traditional learning tools warrant a better performance. Our results are of great interest since this is the first formal study testing this hypothesis.

Many studies tested ChatGPT performance using university exam and medical licensing test questions, to analyze the accuracy of the answers [11–13]. Kung et al. [12] found that ChatGPT answered United States Medical Licensing Exam (USMLE) questions with good accuracy (>50%) and high agreement. Gilson et al. [16] also tested ChatGPT using questions from the USMLE exam. It achieved a passing score, providing logical and informative responses. Conversely, Fijačko et al. [17], showed that ChatGPT failed

Table 1 Subgroup analysis of learning outcomes: univariable and multivariable regression models

Classes	Estimate (± Standard error)	*p*-value
Univariable model		
ChatGPT	Reference	
Lecture	1.2 (±0.8)	0.130
ChatGPT + Lecture	2.7 (±0.8)	< 0.001
Multivariable model (adjusted according to gender, year of course, experience with ChatGPT)		
ChatGPT	Reference	
Lecture	1.0 (±0.8)	0.218
ChatGPT + Lecture	2.6 (±0.8)	0.002
Male		
ChatGPT	Reference	
Lecture	−0.2 (±1.3)	0.893
ChatGPT + Lecture	2.1 (±1.3)	0.110
Female		
ChatGPT	Reference	
Lecture	1.9 (±1.0)	0.052
ChatGPT + Lecture	2.9 (±1.0)	0.004
3rd year study		
ChatGPT	Reference	
Lecture	0.9 (±1.0)	0.375
ChatGPT + Lecture	2.4 (±1.0)	0.018
4th year study		
ChatGPT	Reference	
Lecture	1.8 (±1.3)	0.183
ChatGPT + Lecture	3.2 (±1.3)	0.017
ChatGPT experience		
ChatGPT	Reference	
Lecture	0.9 (±1.2)	0.458
ChatGPT + Lecture	3.0 (±1.2)	0.017
No previous ChatGPT experience		
ChatGPT	Reference	
Lecture	1.4 (±1.2)	0.262
ChatGPT + Lecture	2.1 (±1.1)	0.049

the Basic Life Support (BLS) and Advanced Cardiovascular Life Support (ACLS) exams, despite its scientifically relevant answers. In Eysenbach's study [18], the potential and limits of ChatGPT are empirically and broadly tested through conversation with the tool. In several points the user must direct and correct the chatbot with suggestions about the topics, the correct way to conduct an anamnesis, or provide information to a patient within the simulations carried out. Clear limitations are still those expressed in the interview by ChatGPT itself: the lack of direct generation of diagrams and animations, the absence of critical analysis skills, the lack of access to all scientific articles, the need for professional medical supervision for critical content analysis.

In addition, we addressed all the other different gaps that remain in the ChatGPT usability as a self-learning tool from the neophyte medical students' perspective. Even if the studies show ChatGPT performance supporting its usefulness as a self-learning tool, we obtained lower test evaluation scores with the use of ChatGPT alone compared to the lecture alone. Despite the potential of ChatGPT in self-directed study and improving critical clinical thinking, we demonstrate a higher efficacy of traditional lecture compared to the standalone use of ChatGPT in agreement with the critical analysis carried out by Qu et al. [19]. Recently, Şahin et al. [20] conducted a comparative analysis assessing the accuracy of five chatbots (GPT-4o, Copilot Pro, Gemini Advanced, Claude 3.5, and Sonar Huge) in answering questions from the European Board of Urology In-Service Assessment (ISA), one of the most reliable tools for evaluating urological theoretical knowledge. The results show that chatbots perform better on purely theoretical questions than on those requiring clinical reasoning or interpretation. Of particular relevance is the methodological distinction introduced between factual knowledge and critical clinical thinking, which reveals that current Language Models still struggle with context-based reasoning. These findings reinforce a key point also highlighted in our study: while ChatGPT shows promising potential as a learning tool, its educational effectiveness remains limited in the absence of structured guidance or a solid theoretical foundation. From a pedagogical point of view, Gayef et al. [21] explain how better results are related to intrinsic student motivation and independent learning methods (e.g. ChatGPT). We found higher test scores in students who used ChatGPT + traditional lecture compared to the ones who attended lecture alone. As in the article by Gayef et al., this confirms the usefulness of an independent study method. Analyses show a gradual increase in the evaluation test median scores moving from the use of ChatGPT to lecture only, and finally to the blended use of ChatGPT + lecture. Gayef et al. [21] highlight the chatbot's ability to fabricate scientific references, a phenomenon known as "hallucination", where AI-generated responses contain false information [22]. Similarly, when the teacher used ChatGPT 4.0 to create lecture images, the results lacked medical validity, with texts full of grammatical errors or meaningless content. The studies by Şahin et al. [23] and Malak et al. [24]

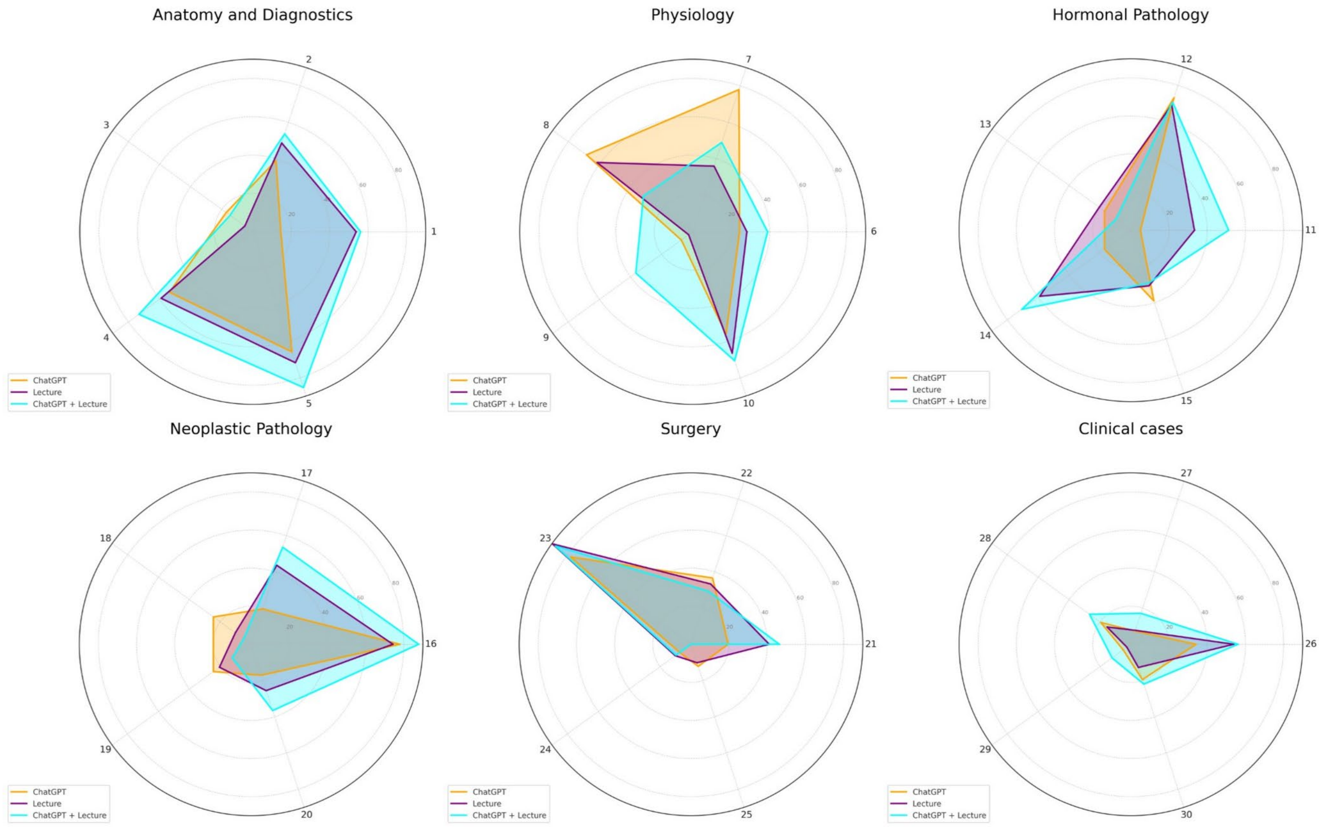
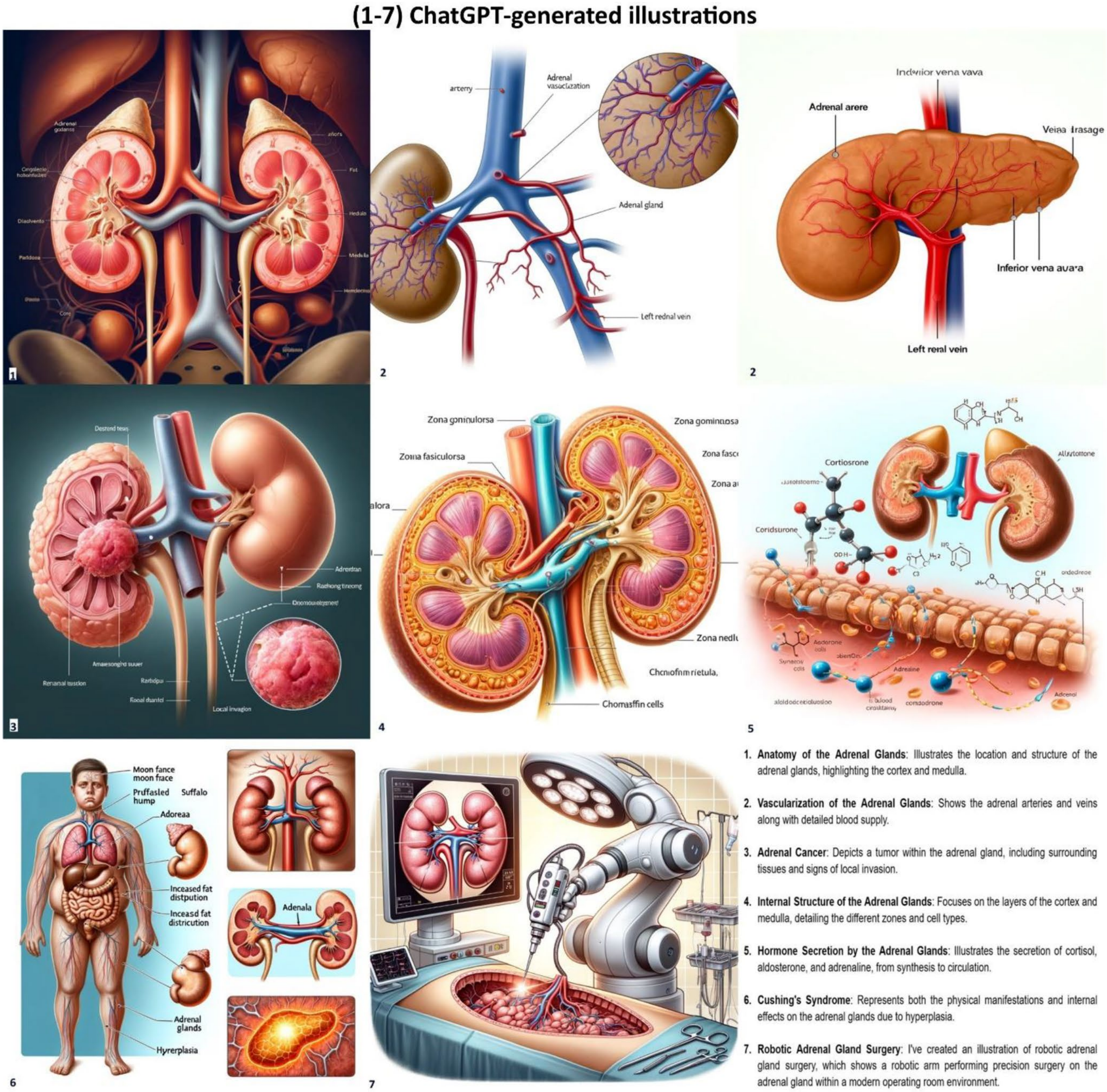


Fig. 3 Radar graphs showing the distribution of correct answers across main topics for each class

compare multiple chatbots, confirming variability in reliability, quality, and the need for prior knowledge or supervision. They also highlight differences in accessibility and comprehensibility, suggesting further research on chatbot roles in self-learning and the impact of accuracy and clarity. Although our study is the first to examine ChatGPT's impact in a structured learning process, it has limitations: a short learning phase and the lack of a repeated evaluation test after a longer period to confirm the effectiveness of different learning approaches or to identify potential variations in outcomes.

Conclusions

Our study confirms ChatGPT's high potential in learning for both educators and learners but highlights its limitations when used without prior knowledge. Key considerations remain persisting limits in scientific reliability and the essential role of teacher guidance. Blended learning (ChatGPT + lecture) is both possible and desirable, as it yields more effective results than the traditional method alone and, moreover, allows for a critical and conscious use of the tool.


(1-7) ChatGPT-generated illustrations

1. **Anatomy of the Adrenal Glands**: Illustrates the location and structure of the adrenal glands, highlighting the cortex and medulla.
2. **Vascularization of the Adrenal Glands**: Shows the adrenal arteries and veins along with detailed blood supply.
3. **Adrenal Cancer**: Depicts a tumor within the adrenal gland, including surrounding tissues and signs of local invasion.
4. **Internal Structure of the Adrenal Glands**: Focuses on the layers of the cortex and medulla, detailing the different zones and cell types.
5. **Hormone Secretion by the Adrenal Glands**: Illustrates the secretion of cortisol, aldosterone, and adrenaline, from synthesis to circulation.
6. **Cushing's Syndrome**: Represents both the physical manifestations and internal effects on the adrenal glands due to hyperplasia.
7. **Robotic Adrenal Gland Surgery**: I've created an illustration of robotic adrenal gland surgery, which shows a robotic arm performing precision surgery on the adrenal gland within a modern operating room environment.

Fig. 4 All images were generated using ChatGPT-4.0. This attempt revealed a deep lack of scientific accuracy in the illustrations, despite ChatGPT describing them as scientifically accurate (as shown in the last image)

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00345-025-05654-w.

Author contributions A. D.: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Visualization A. O.: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Visualization R. C.: Investigation, Data CurationL. S.: Investigation, ResourcesS. D. S.: Investigation, Resources L. D. S.: Investigation, Resources M. V.: Investigation, Resources M. D. N.: Formal analysis, Writing - Review & Editing F. T.: Data Curation M. B.: Data Curation R. D. A.: Data Curation G. S.: Data Curation G. d. S.: Data Curation P. L.: Data Curation L. S.: Supervision, Project administration M. M.: Conceptualization, Methodology, Software, Validation, Formal analysis, Resources, Writing - Review & Editing, Visualization, Supervision, Project administration.

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Data availability Data is provided within the manuscript or supplementary information files.The authors are available to provide the codes and additional materials used in the study upon request from the reviewers.

Code availability The authors are available to provide the codes and materials used in the study upon request from the reviewers.

Declarations

Ethical approval Ethical approval was not required for the present study. All data used in this work are stored anonymized.

Competing interests The authors declare no competing interests.

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