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OPPORTUNITIES FOR USING ARTIFICIAL INTELLIGENCE IN TEACHING FIRST-YEAR MEDICAL STUDENTS

МОЖЛИВОСТІ ВИКОРИСТАННЯ ШТУЧНОГО ІНТЕЛЕКТУ У НАВЧАННІ СТУДЕНТІВ-МЕДИКІВ 1-ГО КУРСУ

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ABSTRACT

Introduction. The introduction of innovative technologies into the educational process can modernise the higher education system and open up new opportunities for student learning. One of these technologies is artificial intelligence (AI), which is actively integrated into the teaching of multiple disciplines and necessary for the acquisition of many professional skills.

Вступ. Сучасною формою системи вищої освіти, що відкриває нові можливості для навчання студентів, є впровадження інноваційних технологій у навчальний процес. Однією з них є штучний інтелект (ШІ), який активно інтегрується у викладання багатьох дисциплін та освоєння професійних навичок.

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Purpose. The purpose of our research is to analyze the attitudes of first-year medical students towards AI and to assess the scope of AI in the study of Medical Biology.

Methodology. A comprehensive analysis of the use of various forms and methods of artificial intelligence was conducted, based on Office 365 Microsoft Teams software. A survey method was used, in which 150 first-year university students specializing in medicine, pediatrics and dentistry responded to the questions. To process the data obtained, the following methods of summarizing and processing the results of experimental studies were used: statistical, graphical and tabular.

Results & Discussion. A survey of these students showed that the majority of them, (around 80%), use a number of AI methods in their studies. Half of them stated that they believe this new technology will have a positive impact on their learning outcomes. Students believe that AI has the potential to become ubiquitous for every higher education student when preparing for class. The level of AI use depends mainly on the complexity of the topic, time constraints, amount of information and automation of routine tasks. In some cases, students use AI when the material is not presented sufficiently clearly, which is determined by the quality of their education. Popular AI tools among students included ChatGPT (90%), Grammarly (50%), Murf, Synthesia (30%), Midjourney (20%), Bing AI, Bard AI (15%) and Speechify (10%).

According to student questionnaires, in their 1st year, AI is most useful in natural sciences that require explanations and visualization, but less effective in humanities and ethics courses. An assessment of the scope of AI in the study of different topics within the discipline of Medical Biology (total 100%) was as follows: Cell division – 20%, Genetics – 30%, Molecular biology – 25%, Evolution – 15%, Ecology – 10%.

Conclusions. There are many benefits to incorporating AI into teaching methods for first-year students. Various AI algorithms for adapting educational material to the student's level of knowledge stimulate the more active participation of students in the educational process, increase motivation and promote an interest in learning. Notwithstanding, the use of AI as a tool, it cannot replace the role of teacher altogether.

Метою дослідження було проаналізувати ставлення студентів-медиків 1-го курсу до ШІ та провести оцінку ступеня використання ШІ при вивченні дисципліни “Медична біологія”.

Методи. Проведено комплексний аналіз застосування різних форм та методів штучного інтелекту на основі програмного продукту Office 365 Microsoft Teams. Використано метод опитування, до якого було залучено студентів першого курсу медичного університету спеціальностей медицина, педіатрія та стоматологія. У дослідженні взяли участь 150 респондентів. Для обробки отриманих даних використовувалися статистичні методи.

Результати та дискусія. Опитування студентів показало, що більшість із них (близько 80%) використовують у своєму навчанні різні форми ШІ. Половина з них вказують, що ця нова технологія позитивно вплине на результати навчання. Студенти вважають, що ШІ має потенціал стати повсюдним для всіх учасників вищої освіти під час підготовки до занять. Рівень використання ШІ залежатиме, в основному, від складності теми, обмеженості часу, обсягу інформації та автоматизації рутинних завдань. У деяких випадках студенти використовують ШІ, якщо матеріал видається недостатньо зрозумілим, що визначається якістю освіти. Популярними ШІ-інструментами серед студентів були: ChatGPT (90%), Grammarly (50%), Murf, Synthesia (30%), Midjourney (20%), Bing AI, Bard AI (15%), Speechify (10%).

Згідно з анкетами студентів, на 1 курсі ШІ найбільш корисний у природних дисциплінах, що потребують пояснень та візуалізації, але менш ефективний у гуманітарних та етичних курсах. Оцінка рівня використання ШІ у вивченні різних тем дисципліни «Медична біологія» (всього 100%) була така: Розподіл клітин – 20%, Генетика – 30%, Молекулярна біологія – 25%, Еволюція – 15%, Екологія – 10%.

Висновок. ШІ дає великі перспективи навчання студентів 1-го курсу. Різні алгоритми ШІ для адаптації навчального матеріалу до рівня знань студента стимулюють більш активну участь студентів в освітньому процесі, підвищують мотивацію та зацікавленість у навчанні. ШІ може бути корисним інструментом, але не повноцінною заміною викладачам

The universal competencies of a doctor can only be fully formed when students gain meaningful experience in activities that take place in the real world of human communication.

Keywords: artificial intelligence, medical education, learning technologies, teaching biology, distance learning.

Універсальні компетенції лікаря повноцінно формуються тільки на основі осмисленого досвіду діяльності, отриманого у реальному середовищі людського спілкування.

Ключові слова: штучний інтелект, медична освіта, технології навчання, викладання біології, дистанційне навчання.

INTRODUCTION

In the contemporary world, medicine is one of the most popular and promising professions. The formation of physician competencies (a set of knowledge, skills and abilities necessary for successful work in the medical field) in first-year medical students is one of the main tasks of the educational system.

Modern medical education requires the introduction of innovative teaching methods to meet the growing volume of scientific knowledge and practical requirements. Today, one of the most preeminent forms of education is a combination of traditional and distance learning ('blended learning') (Yu K. et al., 2018; Skripnik. et al., 2020; Sagan, et al., 2021; Nahaev & Hrynova, 2020).

The effective distribution of educational material is a core component of successful blended learning, to allow for independent processing, as well as time in the classroom with a teacher. This requires the widespread use of modern information and communication technologies. One of these technologies is artificial intelligence, which offers a number of tools that can significantly improve the quality of training (Grimwood et al., 2020; Diwan et al., 2023; Ezzaim et al., 2023; Narayanan et al., 2023; Yurchenko & Nalyvaiko, 2025; Jackson & Jackson, 2024).

The implementation of artificial intelligence (AI) tools in the educational process, including adaptive learning, intelligent student assistance systems and personalization of educational programs is widely discussed in the works of many authors (Luckin, et al., 2016; Grimwood et al., 2020; Narayanan et al., 2023; Alam et al., 2023; Roozafzai, 2024). Studying the possibilities of using this technology is also becoming relevant to mastering the discipline of 'Medical Biology', which is the foundation of fundamental knowledge about the biological processes that affect human health.

The purpose of our research is to analyze the viewpoints of first-year medical students towards AI and to assess the scope of AI in the study of Medical Biology. The goal is to improve the educational process with regard to modern technologies and the quality of teaching. The following goals guided the investigation:

- to analyse the attitude of students towards AI;
- to identify the degree of relevance of AI among medical students;
- to explore popular AI platforms;
- to determine the topics available on relevant programs;
- to determine the scope of AI to assess specific topics in this field.

METHODOLOGY

A comprehensive analysis was conducted into the use of various forms and methods of artificial intelligence, based on Office 365 Microsoft Teams software. To analyze the attitude of students to AI, we conducted an online survey using Google Forms, which comprised of first-year students at the Medical University who were specializing in medicine, pediatrics and dentistry. 150 respondents took part in the study. The methods

of summarizing and processing the results of experimental studies were used: statistical, graphical and tabular and methods of mathematical statistics. As we employed a one-dimensional analysis of the obtained data, descriptive statistics were used to summarize and analyze the results.

RESULTS

A deep mastery of Medical Biology requires not only theoretical study, but also the active use of practical methods, which makes the implementation of AI technologies a useful tool. A survey of students majoring in medicine, pediatrics and dentistry showed that the majority of them (around 80%) use a number of AI tools in their studies. Half of the students surveyed believed that this new technology would have a positive impact on their learning outcomes and would help them to better understand complex biological concepts, by improving the assimilation of material and stimulating an interest in studying biology.

One of our goals was to analyze what exactly motivates medical students to use AI resources and what determines the level of their use.

It was found that several factors determined students' use of AI:

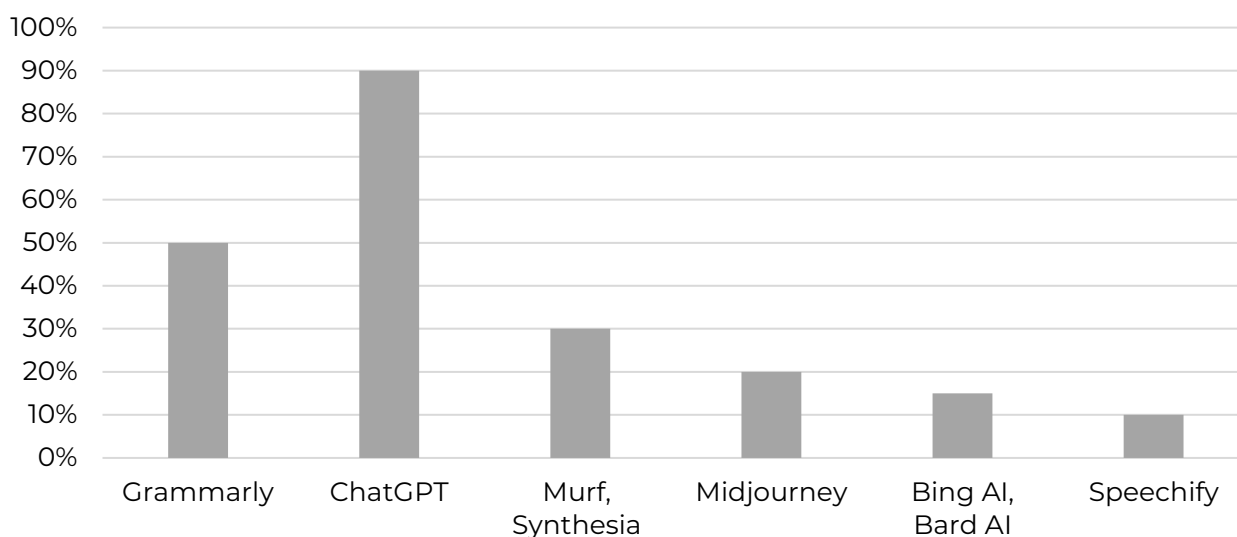
- Complexity of the topic – when material is difficult to understand, students use AI to clear up their doubts.
- Volume of information – AI is helpful in structuring large arrays of data.
- Time constraints – students use AI to speed up the search for information and automate routine tasks.
- Teaching quality – if the material is not presented clearly enough, AI can help to explain the topic more clearly.

The most popular AI tools among students were the following (Fig. 1):

- ChatGPT (90%) – for explaining the material, writing notes.
- Grammarly (50%) – for checking the grammar in scientific papers.
- Murf, Synthesia (30%) – for creating video and audio for presentations.
- Midjourney (20%) – for generating images and visualizations of biological processes.
- Bing AI, Bard AI (15%) – for finding alternative explanations.
- Speechify (10%) – for converting text to audio.

Figure 1

Assessment of the degree of popularity AI tools among students.



Students most often used AI technologies that focused on explaining the mechanisms of biological processes, solving problems, and visualizing chemical processes. Slightly less than half of the respondents were interested in the influence of the teacher and the form in which the training takes place.

Students most actively use AI when studying the following disciplines:

1. Medical Biology – to understand molecular mechanisms, genetics and cell biology.
2. Medical Chemistry – to solve problems and visualize chemical processes.
3. Human Anatomy – for 3D visualization of organs and systems (for example, anatomical simulators based on AI).
4. Physiology – to model processes in the body.
5. Histology – to analyse microscopic images and identify cells and tissues.

Subjects in which AI was used less frequently:

1. Latin and medical terminology – the memorization of individual words and terms is important; AI can only help translate these.
2. History of medicine – requires critical analysis; AI can only select facts.
3. Ethics and deontology – much depends on personal decisions and discussions.

Therefore, in the 1st year, AI is most useful in natural sciences that require explanations and visualization but is less effective in humanities and ethics courses.

An assessment of the level of AI used in studying various topics in Medical Biology (100% total) was as follows (Fig. 2):

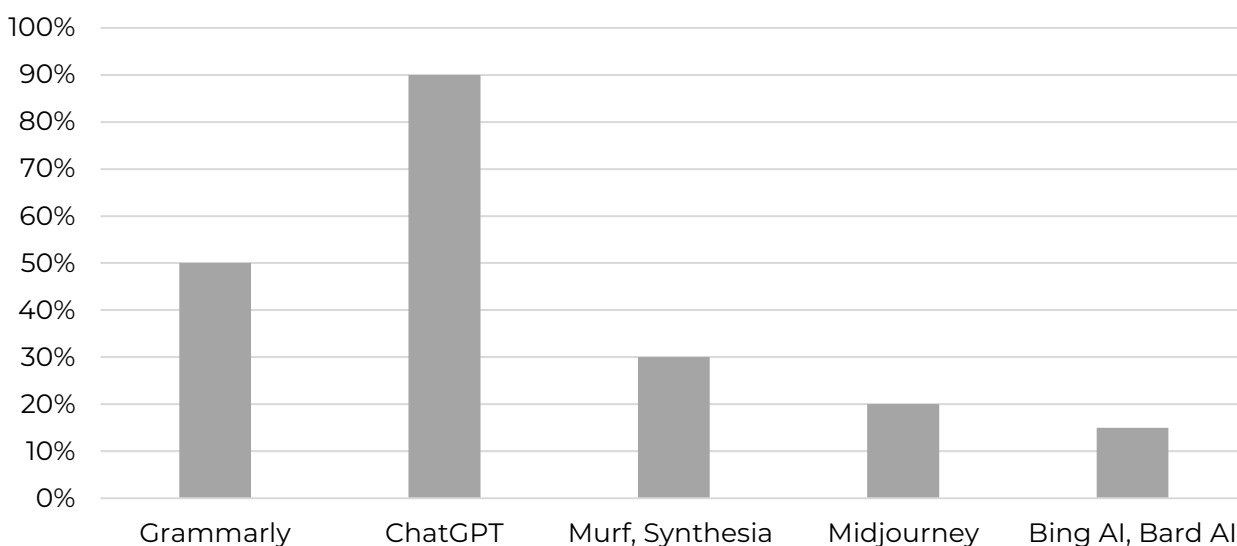
- Cell division – 20%
- Genetics – 30%
- Molecular biology – 25%
- Evolution – 15%
- Ecology – 10%

Topics that required minimal use of AI were:

- classification of organisms (this requires memorization),
- basics of bioethics (where interpretation is important, not algorithmic thinking).

Figure 2

Assessment of the level of AI use in the study of different topics of Medical Biology



The question of how AI helps students prepare for practical classes in Medical Biology yielded results that can be systematized as follows:

1. Generating notes, explanations, and tests:

- ChatGPT (OpenAI) – is helpful in creating notes, explanations, test questions, genetic problems, and solutions.
- Perplexity AI – is able to search for and summarize scientific articles on genetics.
- SciSpace Copilot – explains complex scientific texts in simple language and is helpful in analyzing articles on genetics.
- QuillBot – improves texts and paraphrases material.

2. Knowledge testing:

- Quizlet – can be used to create cards with key terms (genotype, phenotype, allele, etc.).
- Kahoot! – can be used to create interactive quizzes based on Mendel's laws.
- Anki – can be used to create flashcards for memorizing inheritance patterns.
- Google Forms – can be used to create tests and test oneself.

3. Visualization of genetic laws:

- BioRender – for drawing professional diagrams for genetics.
- Canva – for creating infographics to explain Mendel's laws.
- Google Sheets/Excel – for creating Punnett tables.
- Draw.io – for creating family trees for inheritance analysis.

4. Simulations and interactive tools:

- PhET Interactive Simulations (Genetics) – for conducting interactive simulations of genetic experiments.
- Genetics Home Reference (MedlinePlus) – for finding information about genetics in medicine.
- Heredity Simulator – for modelling heredity.

5. Analysis of scientific articles and information retrieval:

- Google Scholar – for searching for information in scientific publications.
- Semantic Scholar – an AI-powered search engine for analysing scientific articles.
- Elicit.org – to help find ideas from scientific articles quickly.

6. Audio and video materials:

- ElevenLabs – to generate the AI-voiceover of texts (and create an audio course).
- YouTube + AI-subtitles – to view lectures with automatic translation.
- Veed.io – for automatically transcribing videos for note taking.

The following is an example of preparing a student for a lesson in Medical Biology using AI (Fig. 3-7).

Figure 3

Lesson plan for 'Medical Biology' using AI and writing notes using ChatGPT

Конспект: Закони Менделя

Грегор Мендель — австрійський монах, засновник генетики. Досліджував спадковість на гороху, що дозволило йому сформулювати основні принципи успадкування.

Основні поняття

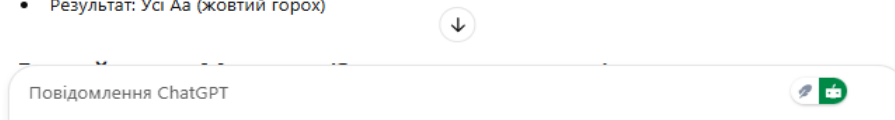
- Ген — одиниця спадкової інформації.
- Алель — різні форми одного і того ж гена (домінантна та рецесивна).
- Гомозигота — організм із двома однаковими алелями (AA або aa).
- Гетерозигота — організм із різними алелями (Aa).
- Генотип — сукупність генів організму.
- Фенотип — зовнішній прояв генотипу (риси, ознаки).

Перший закон Менделя (Закон одноманітності гібридів першого покоління)

Коли схрещуються дві гомозиготні особини, що відрізняються однією парою альтернативних ознак, усе потомство першого покоління буде одноманітним і матиме ознаку одного з батьків.

Приклад:

- Схрещування: AA (жовтий горох) × aa (зелений горох)
- Результат: Усі Aa (жовтий горох)

**Figure 4**

Creating diagrams using BioRender

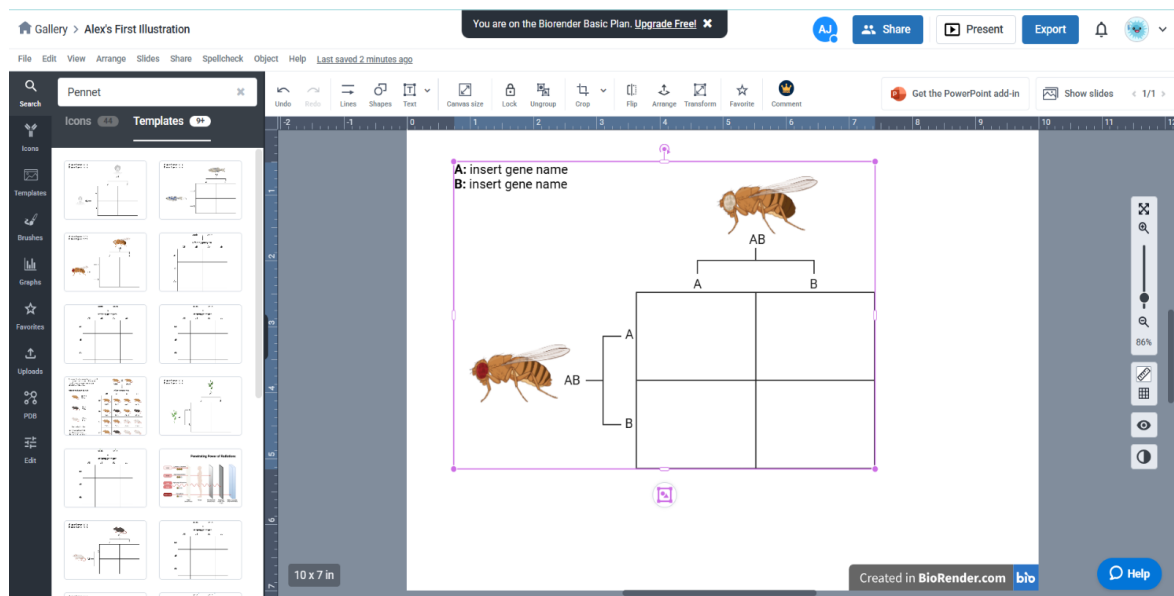


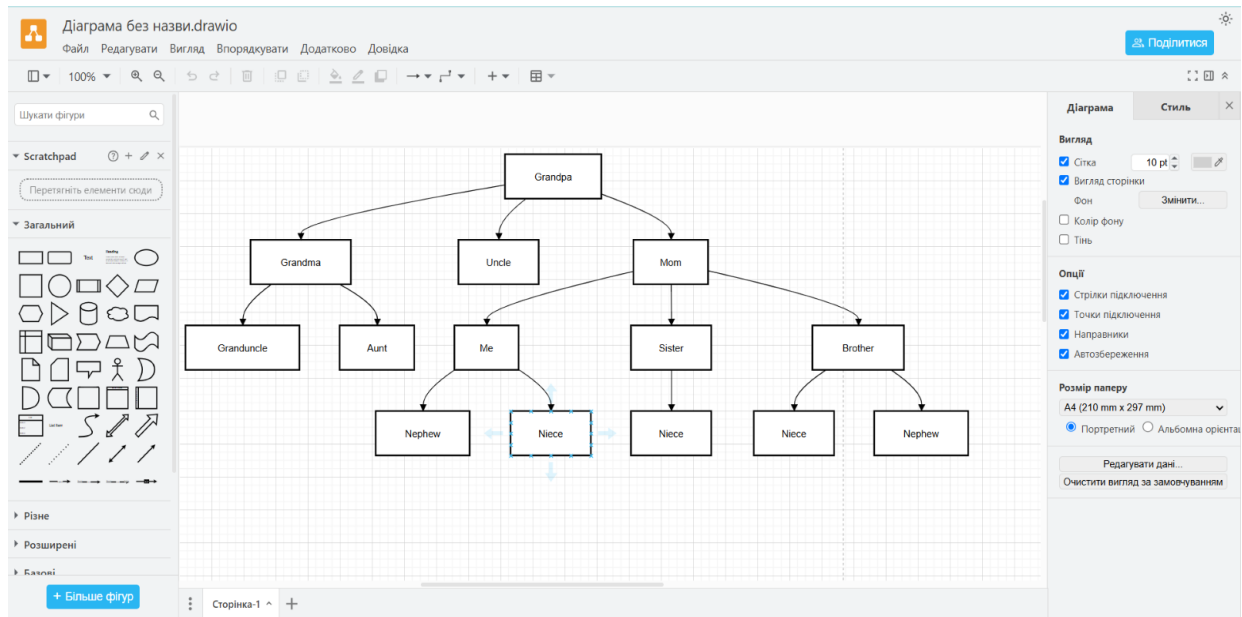
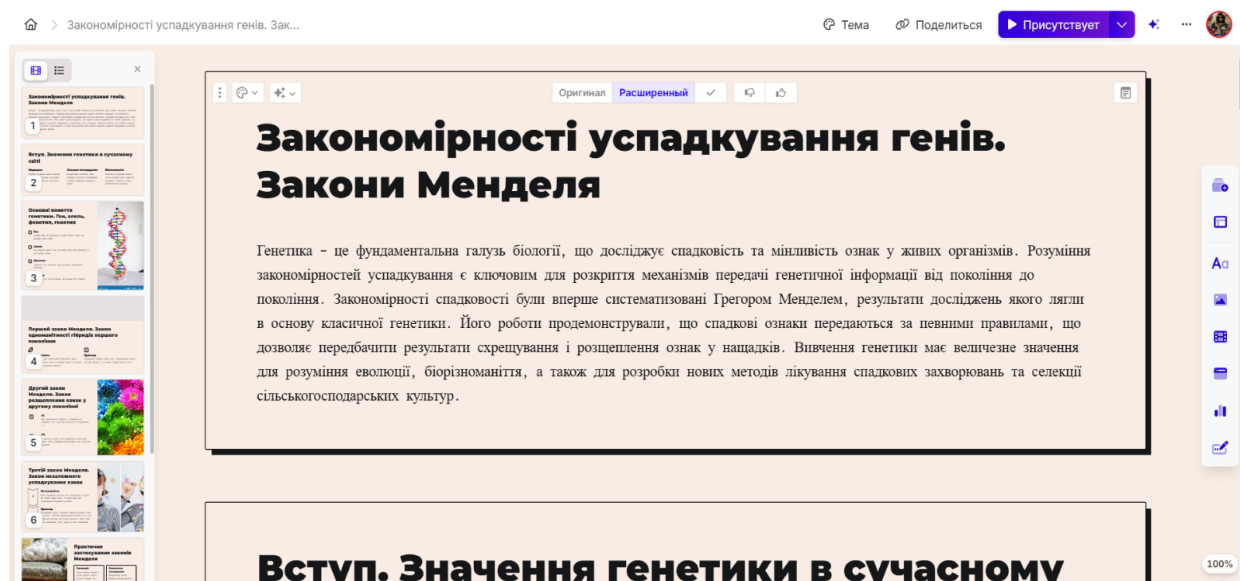
Figure 5*Creating Family Trees with Draw.io.***Figure 6***Modelling Heredity with a Classical Genetics Simulator.*

Figure 7*Creating presentations with Gamma AI*

Artificial intelligence is actively used in teaching Medical Biology students and expands their learning opportunities: AI analyzes huge amounts of biological data, helping students understand complex genetic and cellular processes. In addition, interactive learning materials are developed using AI, including virtual labs and 3D models, which provide a deeper understanding of anatomy and physiology. Finally, intelligent systems can adapt the level of difficulty to each student's individual learning style, and offer additional resources. Based on our research, here are some examples of how artificial intelligence can be applied in Medical Biology classes:

1. **Virtual labs:** AI allows you to create interactive simulations of biological processes, such as DNA replication.
2. **Data Analysis:** AI helps students work with large amounts of data, such as those found in the fields genomics, proteomics and bioinformatics. AI can help students study genetic sequences, find mutations, and analyze their impact on health.
3. **Development of Critical Thinking** - Case Study: AI can generate problem scenarios that require students to analyze, search for information, and make decisions.

Here is an example of a real-world case study for students to investigate:

Topic: Identification of a genetic mutation associated with a rare disease.

1. **Case Description:** A sixteen-year-old female patient complains of chronic fatigue, muscle weakness, and frequent cramps. Doctors suspect mitochondrial disease. Her genome is sequenced to clarify the diagnosis.
2. **Objective of the task:** Students must use AI to:
 - Find a mutation in mitochondrial DNA (for example, in the MT-TL1 gene).
 - Assess its impact on cell function.
3. **Practical parts:**
 - Students upload the sequencing data (real or simulated) to an AI platform such as Google Colab with Python libraries (Biopython, Scikit-learn).

- They analyze the data using algorithms to find single nucleotide substitutions or deletions.
- They interpret how the mutation affects protein synthesis and metabolism.

4. Conclusion: After they complete their analysis, students present a hypothesis: how the mutation they detected lead to mitochondrial dysfunction, decreased energy in the cells and the appearance of symptoms in the patient.

This case study manages to integrate genetics, molecular biology and medical aspects in one task.

Simplified version of a case study:

Topic: *Predisposition to lactose intolerance.*

- 1. Case Description:** A patient is experiencing bloating and discomfort after consuming dairy products. The doctor suspects genetic lactose intolerance.
- 2. Task Objective:** Determine whether the patient has a mutation in the LCT gene associated with decreased lactase production.
- 3. Practical Part:** Students are given a short DNA sequence of the patient (e.g., a section of the LCT gene). They use an AI tool (or a simulated program) to compare this sequence with a reference sequence. They find a key mutation (e.g., C instead of T in a certain position).
- 4. Conclusion:** If a mutation is found, students explain how it is related to the patient's symptoms and offer medical advice (e.g., to limit dairy products or use enzymes that break down lactose).

This is a straightforward case, even for students who are just beginning to study genetics and does not require complex technical skills.

Artificial intelligence (AI) is being used to study several parasites, including worms, lice, and fleas, which pose a threat to human health. These parasites have complex morphology and life cycles, which makes them difficult to study. AI helps model these cycles, predicting key stages of parasite development and transmission. For example, AI can identify factors that affect the success of reproduction or infection, such as climate conditions, host behavior, or ecosystem features. Deep learning helps create 3D models of parasites, making it easier to study their anatomy and behavior. Such models are especially important for disease diagnosis and prevention, as well as for the control of parasites transmitted through water, soil, or insects. The use of AI enables an automated analysis, the identification of patterns, and the development of effective control measures. Here is one example of a preliminary diagnosis using AI.

- 1. Problem:** A cyst with a chitinous and proteinaceous membrane filled with a colorless, transparent fluid is found in the liver.
- 2. Objective:** What disease can present in this way?
- 3. Discussion:** Key features:
 - Chitinous and proteinaceous membrane → The wall of the cyst in echinococcosis consists of an outermost layer and an inner germinal layer.
 - Colorless, transparent fluid → Echinococcal cysts usually contain a clear, non-cloudy fluid.
 - Liver involvement → The liver is the most common organ affected by echinococcosis.

4. Differential diagnosis:

- Cysticercosis (caused by *Taenia solium*) can form cysts, but they are usually smaller and not associated with a chitinous wall.
- Amebic liver abscess (caused by *Entamoeba histolytica*) contains pus rather than clear fluid.
- Simple liver cysts (congenital or acquired) do not have a chitinous membrane.

5. Preliminary diagnosis. The available data suggests an echinococcosis cyst, which is characteristic of echinococcosis, a parasitic disease caused by the tapeworm *Echinococcus granulosus* or *Echinococcus multilocularis*.

Medical biology is the study of the biological processes that underlie human health and disease. As one of the key disciplines in the initial stages of medical education, Medical Biology covers the fundamentals of genetics, molecular biology, parasitology and biotechnology, to provide students with a basic understanding of biological processes. Many topics in Medical Biology are very complex, the complexity of which depends on several factors: the training level of the students, the amount of theoretical material, the presence of practical skills and the need to apply analytical thinking. Such topics require further explanation, as well as diagrams and practical skills in order for students to assimilate the material, which is only possible with the direct participation of both the teacher and the student. Some of the topics are the following:

1. Molecular basis of heredity. Characteristics of nucleic acids. Gene structure: require knowledge of biochemistry, DNA structure and its replication. Molecular processes can be difficult to understand without additional visual materials.
2. Organization of information flows in the cell. Regulation of gene activity: the topic is complex due to the need to understand transcription, translation and epigenetic mechanisms.
3. Morphology of chromosomes. Human karyotype. Life cycle of the cell. Mitosis: it is important to not only know the structure of chromosomes, but also to understand the processes of mitosis and meiosis, which require clear visualization.
4. Patterns of gene inheritance. Mendel's Law: Genetic patterns can sometimes cause difficulties due to the need to work with them, including understanding dominance and the inheritance of recessive traits.
5. Molecular diseases. Biochemical method and DNA diagnostics: require knowledge of biochemistry and genetic diagnostic methods, which may be difficult for students without a basic knowledge of molecular biology.
6. Cytogenetic method. Chromosomal diseases. Difficulties may arise due to the need to analyze karyotypes and recognize pathologies at the chromosome level.

DISCUSSION

Our research, as well as the research of other authors (Patel, et al.,2009; Luckin, et al.,2016) have shown that many interactive educational materials have been developed using AI, including virtual labs and 3D models, which allow for a more in-depth study of many software disciplines. In addition, intelligent systems can adapt to the individual learning style of each student, to modify how complex the material is, and provide additional resources. However, the training of medical students should include not only the study of theoretical disciplines, but also the development of professional communication.

Communication skills are an integral part of the professional activity of a doctor. Effective interaction with patients, colleagues and medical staff affects diagnostic accuracy, as well as the successful treatment and the psychological well-being of the patient. In modern medicine, communication between a doctor and a patient plays an important role. Lack of communication skills can lead to a lack of patient trust, errors in treatment and conflict in the medical environment. Developing communication skills is an important part of medical education. The use of an integrated approach, including role-playing games, feedback and modern technologies, improves the quality of training of future doctors and contributes to the improvement of medical care; developing communication skills requires constant communication both among students and with teachers.

CONCLUSIONS

The use of AI offers several advantages: high data processing speed, reduced human error and the ability to analyze large amounts of information. However, there are still challenges. AI training requires high-quality and diverse data, which is not always available. In addition, the complexity of some models makes it difficult to interpret the results, which requires the assistance of specialists.

It should also be noted that an important area in the training of a doctor is the formation of communication skills with patients, as well as empathy and the ability to explain complex medical terms in simple language. These qualities are formed only through continuous real-time communication.

The interaction of the teacher, who plays a leading role and the student body ensures personal growth and the spiritual and creative enrichment of both parties. Artificial intelligence is not able to think, analyze, read carefully, compare the answer with the question or evaluate the answers. It is just an algorithm. Communication with AI will not replace a teacher.

To eliminate this problem, emphasis should be placed on the development of critical thinking, the creation of creative tasks, and oral conversations to control knowledge.

CONFLICT OF INTERESTS

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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REFERENCES

- Alam, F., Lim, M. A., & Zulkipli, I. N. (2023). Integrating AI in medical education: embracing ethical usage and critical understanding. *Frontiers in Medicine*, 10, 1279707. <https://doi.org/10.3389/fmed.2023.1279707>
- Diwan, A., Srinivasa, S., Suri, G., Agarwal, S., & Ram, P. (2023). AI-based learning content generation and learning pathway augmentation to increase learner engagement. *Computers and Education Artificial Intelligence*, 4, 100110. <https://doi.org/10.1016/j.caeai.2022.100110>
- Ezzaim, A., Dahbi, A., Haidine, A., & Aqqal, A. (2023). AI-Based Adaptive Learning: A Systematic mapping of literature. *JUCS – Journal of Universal Computer Science*, 29(10), 1161–1198. <https://doi.org/10.3897/jucs.90528>

- Grimwood, T., & Snell, L. (2020). The use of technology in healthcare education: A literature review. *MedEdPublish*, 9, 137. <https://doi.org/10.15694/mep.2020.000137.1>
- Jackson, E. A., & Jackson, H. F. (2024). Enhancing Human Knowledge and Capabilities with Artificial Intelligence Tools for Education. *Educational Challenges*, 29(2), 139–150. <https://doi.org/10.34142/2709-7986.2024.29.2.09>
- Luckin, R., Holmes, W., Griffiths, M., & Forcier, L. B. (2016). *Intelligence Unleashed: An Argument for AI in Education*. Pearson Education. <https://www.researchgate.net/publication/299561597>
- Nahaev, V., & Hrynova, Y. (2020). Pedagogical Model of Organization of Distance Teaching and Learning in the Conditions of Network Technology of Students' Educational and Creative Activity Management. *Educational Challenges*, 25(1), 82–95. <https://doi.org/10.34142/2709-7986.2020.25.1.07>
- Narayanan, S., Ramakrishnan, R., Durairaj, E., & Das, A. (2023). Artificial Intelligence Revolutionizing the Field of Medical Education. *Cureus*, 15(11), e49604. <https://doi.org/10.7759/cureus.49604>
- Patel, V. L., Shortliffe, E. H., Stefanelli, M., Szolovits, P., Berthold, M. R., Bellazzi, R., & Abu-Hanna, A. (2009). The coming of age of artificial intelligence in medicine. *Artificial intelligence in medicine*, 46(1), 5–17. <https://doi.org/10.1016/j.artmed.2008.07.017>
- Roozafzai, Z. S. (2024). Artificial Intelligence Assistance and Cognitive Abilities: Harnessing AI-Assisted Heuristic Methods for Transitioning from Critical to Creative Thinking in English Language Learning. *Educational Challenges*, 29(2), 339–361. <https://doi.org/10.34142/2709-7986.2024.29.2.23>
- Sagan, N. T., Zayats, L. M., Zhurakivska, O. Ya., Antymys O.V., Dutchak U.M., & Miskiv V.A. (2021). Dystantsiine navchannia v medychnomu vuzi – realii sohodennia [Distance learning in a medical university – the realities of today]. *Innovatsiina pedahohika – Innovative pedagogy*, 31(1), 153–156. <https://doi.org/10.32843/2663-6085/2021/31-1.32> [in Ukrainian].
- Skripnik, I. M., Maslova, G. S., Prikhodko, N. P., Hopko, O. F., & Shaposhnyk, O. A. (2020). The use of distance methods in medical education. *Problems of continuous medical education and science*, 3, 29–31. <https://repository.pdmu.edu.ua/handle/123456789/13709> [in Ukrainian].
- Skrypnyk, I.M., Maslova, G.S., Prykhodko, N.P., Gopko, O.F., & Shaposhnyk, O.A. (2020). Vykorystannia dystantsiinykh metodiv navchannia v medychniy osviti [Using of distance education methods in medical education]. *Problemy bezperervnoi medychnoi osvity ta nauky – Problems of Uninterrupted Medical Training and Science*, 3 (39), 29–32 [in Ukrainian].
- Yu, K.H., Beam, A.L., & Kohane, I.S. (2018) Artificial Intelligence in Healthcare. *Nature Biomedical Engineering*, 2, 719–731. <https://doi.org/10.1038/s41551-018-0305-z>
- Yurchenko, V., & Nalyvaiko, O. (2025). How ChatGPT shapes a new reality of writing: Is there a place for humans in an artificial world?. *Educational Challenges*, 30(1), 138–155. <https://doi.org/10.34142/2709-7986.2025.30.1.09>