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DEVELOPING DATA INTERPRETATION SKILLS OF FUTURE BIOLOGY TEACHERS USING ARTIFICIAL INTELLIGENCE TOOLS

Abstract

Artificial intelligence (AI) technologies have accelerated rapidly, presenting novel opportunities to the teaching and learning processes in higher education. These tools are used to develop data interpretation skills for future biology teachers, which was the focus of this study. This study was carried out on 54 first-year master's students at Abai Kazakh National Pedagogical University enrolled in the 7M01513 – Biology educational program. The design was quasi-experimental, with diagnostic, formative and control phases. In the formative phase, students were utilising artificial intelligence tools like ChatGPT, Gemini, Claude, Copilot, Napkin AI to explore biological data, determine the significance of research findings, produce evidence-based conclusions, and form visual representations of scientific data. Data were collected via the implementation of diagnostic tests, practical tasks, assessment rubrics and questionnaires. Results were analyzed using percentages, means, and statistical methods. The results also had a positive effect on students' ability to interpret data using AI-supported learning. Participants at high proficiency-level improved from 16.7% to 33.3% compared to low level, where from 38.9% to 16.7%. There was an improvement in the students' processing data, interpretation, visualization and scientific reasoning skills. The paper reports a conclusion that artificial intelligence tools can support the enhancement of data interpretation competencies among our next generation of biology teachers and the transformation of the biology teaching and learning environment.

Keywords: artificial intelligence, biology education, future biology teachers, data interpretation, digital learning.

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БОЛАШАҚ БИОЛОГ МҰҒАЛІМДЕРІНІҢ ДЕРЕКТЕРДІ ИНТЕРПРЕТАЦИЯЛАУ ДАҒДЫЛАРЫН ЖАСАНДЫ ИНТЕЛЛЕКТ ҚҰРАЛДАРЫ АРҚЫЛЫ ТИІМДІ ДАМУ

Аңдатпа

Жасанды интеллект технологияларының жылдам дамуы жоғары білім беру жүйесін жаңғырту және оқыту тәжірибесін жақсарту үшін көптеген мүмкіндіктер жасады. Бұл зерттеу болашақ биология мұғалімдерін деректерді талдауға дайындаудағы жасанды интеллект құралдарының тиімділігін талдауды мақсат етеді. Бұл зерттеу Абай атындағы Қазақ ұлттық педагогикалық университетінің 7M01513 - Биология білім беру бағдарламасының 1-курс магистранттары арасында жүргізілді. Жалпы, зерттеуге 54 магистрант қатысты. Зерттеу диагностикалық, қалыптастырушы және бақылау кезеңдерін қамтитын квази-эксперименттік дизайнды қолданды. Осы кезеңде білім беру бөлімі оқу процесіне ChatGPT, Gemini, Claude, Copilot және Napkin AI сияқты құралдарды енгізді. Магистранттар биология деректерін талдау, ғылыми нәтижелерді оқу, дәлелдерге негізделген қорытындылар жасау және деректерді визуализациялау бойынша тапсырмаларды орындауы керек болды. Деректер диагностикалық тесттер, практикалық жобалар, бағалау рубрикалары және сауалнамалар арқылы жиналды. Талдау пайыздық талдау, орташа мәндерді есептеу және статистикалық өңдеу әдістері арқылы жүргізілді. Нәтижелер жасанды интеллект құралдарының студенттерге оң әсер ететінін көрсетті. Жоғары деңгейлі студенттердің үлесі 16,7%-дан 33,3%-ға дейін өсті, ал төмен деңгейлі студенттердің пайызы 38,9%-дан 16,7%-ға дейін төмендеді. Сонымен қатар, қатысушылардың талдау, интерпретация, визуализация және ғылыми ойлау қабілеттері айтарлықтай жақсарды. Жасанды интеллект құралдары болашақ биология мұғалімдерінің білімін деректерді интерпретациялау құзыреттілігі және биологиялық мұғалімдердің компьютерлендірілген білімі тұрғысынан дамытуда табысты әдістер екенін дәлелдеді.

Түйін сөздер: жасанды интеллект, биологиялық білім беру, болашақ биология мұғалімдері, деректерді интерпретациялау, цифрлық педагогика, цифрлық оқыту.

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РАЗВИТИЕ НАВЫКОВ ИНТЕРПРЕТАЦИИ ДАННЫХ БУДУЩИХ УЧИТЕЛЕЙ БИОЛОГИИ СРЕДСТВАМИ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА

Аннотация

В дополнение к созданию новых зон для учебы студентов, быстрое развитие технологий искусственного интеллекта открывает новые возможности для улучшения образования и повышения качества подготовки будущих специалистов. Это исследование направлено на выяснение роли инструментов искусственного интеллекта в обучении студентов интерпретации данных для преподавания биологии. В выборку вошли 54 студента первого курса магистратуры по программе 7M01513 – Биология, под эгидой Казахского национального педагогического университета имени Абая. В работе использовался квазиэкспериментальный исследовательский дизайн, состоящий из констатирующего, формирующего и контрольного этапов. На формирующем этапе были внедрены инструменты искусственного интеллекта, такие как ChatGPT, Gemini, Claude, Copilot и Napkin AI, для обучения предметам. Магистранты выполняли работу, включающую анализ биологических данных; интерпретацию научных выводов; формулирование выводов, которые можно обосновать полученными данными, и визуализацию информации. Данные собирались с помощью диагностических тестов, практических заданий, оценочных рубрик, а также анкетирования. Вычисленные средние значения анализировались статистически, через процентный анализ, расчет средних значений и статистические методы. Результаты были представлены в виде результатов исследования. Выводы показали улучшение навыков интерпретации данных, полученных с помощью инструментов искусственного интеллекта. Доля студентов с высоким уровнем подготовки возросла с 16,7% до 33,3%, и это немного меньше процента с низким уровнем подготовки, который снизился с 38,9% до 16,7%. У испытуемых повысились способности к анализу данных (интерпретация, визуализация, научное обоснование выводов). Результаты показывают, что методы, основанные на искусственном интеллекте, эффективны для формирования способности к интерпретации данных у будущих учителей биологии и для цифровой трансформации биологического образования.

Ключевые слова: искусственный интеллект, биологическое образование, будущие учителя биологии, интерпретация данных, цифровое обучение.

Introduction. The digital industry is quickly changing and new technologies and artificial intelligence (AI) increasingly dominate this revolution. Preparing teachers is more than just knowing the content of the subject. Future biology teachers need to handle data, analyse the results and successfully implement digital tools in their learning and teaching processes (Haleem et al., 2022). The strategic priorities of the Republic of Kazakhstan reflect the critical importance of educational digitalization. President Kassym-Jomart Tokayev has repeatedly highlighted the importance of integrating advanced technologies into education to prepare specialists to take on the challenges of the digital era in his state-of-the-nation addresses (Toqayev, 2023). Now biology is increasingly becoming a data-driven science. Both students and educators work with ecological, genetic, physiological, and biomedical data on a regular basis. Consequently, data interpretation forms an integral part of the professional practice for new biology teachers. Existing teaching techniques, however, do not always offer enough opportunities for development of such competencies in a digitally mediated context (Zha et al., 2025). Today, AI tools like ChatGPT, Gemini, Claude, and Copilot provide new ways to analyze, visualise, and interpret data. These technologies are able to help students grasp complex biological concepts as well as to raise the quality of academic learning. Hence, the prospects of AI-based tools for fostering future biology teachers' ability to interpret data are thus both topical and relevant. These findings may help facilitate the digital transformation of biology teacher education and may also provide concrete guidance with regard to the operationalization of AI into the learning process (Chiu et al., 2023).

Data interpretation is a skill that is very important in teaching biology. Data is a tool of biology's development. Studies of genetics and physiology, ecology and biomedicine, as well as knowledge in these disciplines, continue to collect vast amounts of information that students will need to process and understand (Cochrane et al., 2026). Interpreting the data allows learners to recognize trends, clarify biological processes, and conclude on the basis of evidence. It also enhances critical thinking and

scientific literacy in students. Such competencies, in turn, are critical to the understanding of complex biological systems and to solving modern environmental and health-related problems (Ng et al., 2021). But to future biology teachers, data interpretation is much bigger than an academic skill. It is a professional imperative in schools. Teachers who are confident to analyze and explain biological data are prepared to facilitate inquiry-based learning as well as to direct student experimentation and evidence-led reasoning in the classroom (Luckin & Holmes, 2016). As science education is constantly undergoing digital transformation, the education of data interpretation abilities has entered the top of the agenda of biology teacher education. It is in these types of skills that future educators will be able to compete in an era of technology-rich learning and respond effectively to the challenges of contemporary biological science (Holmes et al., 2019).

Current trends of utilization of AI-based approaches in education. Artificial Intelligence is changing the face of education. Nowadays, AI tools are utilized for both information retrieval and for learning assistance, assessment, research and content creation (Zawacki-Richter et al., 2019). Generative AI platforms like ChatGPT, Gemini, Claude, and Copilot represent the most recent and notable advancement. They can respond to questions, explore the information, develop the learning materials, and offer personalized feedback. Thus, they are becoming useful assistants to students and teachers (Kasneci et al., 2023). Another emerging trend is the use of AI for data analysis and visualization. Tools powered by AI can sift through huge datasets, spot meaningful patterns and present information in easily consumable style. In biology education, this represents a fresh opportunity for explaining experimental findings, ecological observations, and other scientific information (Funk et al., 2026). Indeed, it is not just technical accessibility that is necessary for AI integration to succeed. How to teach future teachers will require tools to assess AI content critically and implement it responsibly. Due to AI development being a key topic of study, AI literacy and practical experience with AI tools have emerged as an important target area of current teacher education (Äbıltaeva & Jūmağūlova, 2025).

Research Problem. Artificial intelligence is playing a central role in modern education. New AI tools help learning, data analysis, and problem-solving. But many future biology teachers have a hard time trying to read biological data and make conclusions grounded in evidence. This problem is even more critical to biology, which is known to rely more and more on interaction with scientific data to learn. Traditional methods of teaching tend to place more value on rote memorization than analytical skill building. Consequently, a lack of biological dataset skills in the student will be the reason for the students being unable to perform effectively in such a dataset. While AI technologies are widely discussed in education, their role in teaching future biology teachers and their use in data interpretation skills is not yet explored. This highlights the need for study on how AI tools can facilitate development of these crucial professional skills.

Research Objective. The goal of this study is to evaluate the role of artificial intelligence tools in developing the data interpretation skills of future biology teachers. The study explores students' skill set in analyzing, interpreting, visualizing, and explaining biological data.

Research Hypothesis. The study anticipates that a systematic use of artificial intelligence tools may better hone future biology teachers' data interpretation skills. It is anticipated that AI-supported lesson plans will also improve the performance of students on data analysis, interpretation, visualization, and evidence-based reasoning more than traditional teaching methods.

Materials and methods. Using a quasi-experimental design this study investigated the effect of artificial intelligence tools on the development of data interpretation skills among future biology teachers. Quantitative and qualitative data were also collected to monitor students' performance change during the study. The experiment had three steps (diagnostic, formative and control). This architecture enabled us to identify the starting point of participants' abilities, to deliver AI-based learning experience within different activities, and to evaluate effects on outcomes.

The studies were carried out in the Department of Biology, Faculty of Natural Sciences and Geography, Abai Kazakh National Pedagogical University. Participants were 54 first-year master's students enrolled in the 7M01513 - Biology educational program. They were all seeking careers in

biology education. They are chosen as data interpretation and digital competence are becoming significant components of modern teacher preparation.

The initial stage was to identify the baseline level of data interpretation ability of students. Diagnostic tasks that asked participants to analyze, interpret, and explain biological data were completed. These results served as a start for assessing additional gains. Formative Stage. AI tools such as ChatGPT, Gemini, Claude, and Copilot were at this stage utilized in learning exercises. Students handled biological datasets, interpreted results, created visualizations, and developed evidence-based explanations to strengthen their analysis and understanding of scientific information using AI support. Control Stage. The final step assessed the success of the intervention. Students performed post-test tasks as applied in the diagnostic stage. Findings were then corroborated against the preliminary results to assess the influence of AI tools on the development of data interpretation skills.

Four methods of data collection were used to assess the development of skills in interpreting data: diagnostic test, practical tasks, assessment rubric, and questionnaire. These tools yielded a detailed picture of students' abilities and progress in learning, as well as their opinions on AI-assisted learning. Data collection instruments (in this study) are presented in Figure 1.

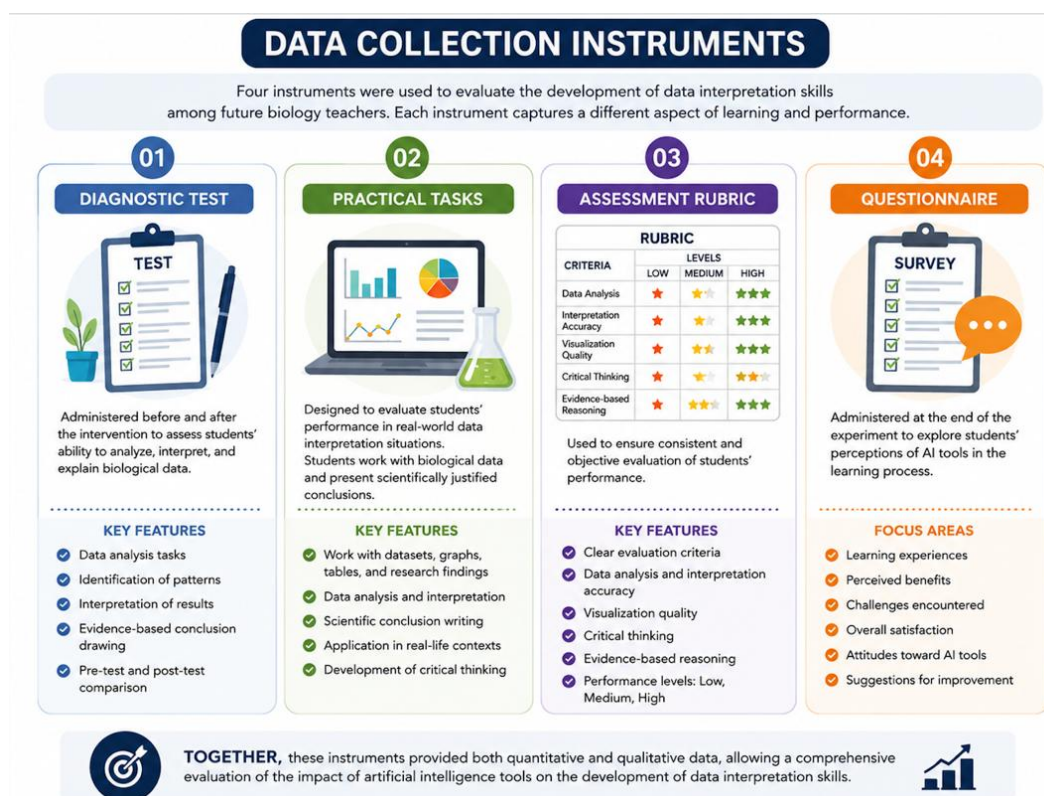


Figure 1. Instruments utilized to conduct the evaluation of the interpretation based data abilities of prospective Biology Teachers

Such AI devices were fundamental to this research. These helped students to analyze biological information, interpret results, generate explanations, and visualize scientific information. Tools selected were based on their accessibility, educational value, and relevance to biology teacher education. ChatGPT acted as the main AI tool throughout the experimentation. It helped the students make sense of biological data, clarify dense scientific concepts, and arrive at evidence-based conclusions. The students analyzed graphs, tables, and experimental results with the platform. Also, it provided instant feedback to help shape up their interpretations and bolster scientific reasoning. Gemini supported searching for information and looking for data. Students used it to find scientific information, compare sources, and organize scientific knowledge. The tool proved beneficial, particularly in dealing with ecological,

physiological, and genetic data where it needed more context and explanation. Copilot assisted students in organizing and formulating clear explanations. It was utilized for paraphrasing scientific texts, identifying main conclusions, and sorting biological information. The platform also facilitated the presentation of information and helped people draw logical conclusions about the data. Claude was used for more in-depth research in order to delve deeper with the science behind it. It was used for students to analyze scientific data by means of the application of the tools such as Claude. Students applied it to research results to investigate research findings, appraise evidence, investigate supporting material, and develop well-reasoned arguments supported by a coherent rationale based on empirical evidence. The instrument fostered critical analysis and encouraged critical thinking and was linked to analytical thinking. Napkin AI was used to visualize throughout the study. Students converted text into image, graphics, concept map, flow chart, and infographic. These visualizations simplified complex biological interrelations and contributed to better interpretation of research data. Combined, these AI tools facilitated a more interactive learning process. They fostered active interaction with biological information, and promoted data interpretation skills in future biology teachers.

Criteria for Assessing Data Interpretation Skills. Four major criteria assessed an individual's development of data interpretation skills. The criteria combined indicated students' ability to work with biological content of the data, make evidence-based explanations, and then communicate what works according to scientific interpretation. **Data Analysis.** This indicator was concerned with whether students were able to look up biological data and discern patterns, trends, and interactions. It was proposed that the participants should compare datasets and identify key findings and extract pertinent findings. **Good exam showing systematic and analytical skills.** **Data Interpretation.** This objective tested students' ability to interpret biological data based on evidence they had. Subjects explained experimental findings, their explanation of biology, and their justification of their responses. Specific care in the correctness and logic of their explanations was given. **Drawing Conclusions.** This criterion evaluated students' skills in constructing conclusions drawn from data analyzed. Respondents synthesized information, justified their explanations, and created evidence-based arguments. Successful conclusions exemplified a clear link between data and scientific reasoning. **Interpretation of results of visualization.** This standard assessed students' interactivity with visual information. Participants were encouraged to interpret graphs, charts, diagrams, and other visual representations of biological data. We were really concentrating on trends, relationships, communicating accurately. **Statistical Data Analysis.** Descriptive and inferential statistics were performed on the collected data. Such strategies facilitated the assessment of the modification impact on the students' performance of AI-based learning tasks before and after using such AI-driven learning activities. **Percentage Analysis.** The distribution of participants on the basis of low, medium, and high data interpretation ability can be calculated by the percentage analysis. So you can get a sense of learning progress against that in the progress of a course, and how well you are still learning. **Mean Scores.** Measures of average to compare where participants' performance at different points in the study. These results allowed general trends to be identified and to quantify improvement. **Testing for Statistical Significance.** Inferential Statistic analysis was performed to demonstrate if the changes were significant. Based on the data type, either the independent samples t-test or chi-square (χ^2) test were used. As such, it is now possible to objectively evaluate the effectiveness of an intervention. **Statistical Software.** Data analysis and processing were performed in Microsoft Excel and IBM SPSS Statistics. The software also supported the organization of data, statistical calculation, hypothesis testing, and graphical representation of results.

Results. **Initial Diagnostic Results.** The diagnostic stage for data analysis of first-year master's students in 7M01513 – Biology was performed to ascertain the background of data interpretation skills by the first-year master's students in the 7M01513 – Biology program. Data analysis, interpretation, conclusion drawing, and visualization interpretation were carried out before the intervention. Most students' proficiency levels were medium and low. They could find rudimentary data from biological datasets but found it difficult to describe relationships and explain complex results, to infer from it, and to make claims based on evidence. Graphs, charts, and other graphical representations of the biological

data were not without their difficulties when dealing with graphics and the like. Findings indicated that although participants had sufficient knowledge of biology, data interpretation skills need further development. They also validated the importance of adding artificial intelligence tools to their learning so that advanced analytics and interpretation capabilities are improved. Participants were divided on a classification scale based on the diagnostic survey into three groups based on the following levels according to a diagnostic assessment: high, medium, and low (Table 1).

Table 1 – Initial Level of Data Interpretation Skills

Level	Number of Participants	Percentage (%)
 High	9	16.7
 Medium	24	44.4
 Low	21	38.9
 Total	54	100

The highest level of medium-level data interpretation skills was exhibited by participants (44.4%), as illustrated in Table 1. Another 38.9% were rated as low level and 16.7% were high level. Overall, these results suggest that the significant majority of students did not possess the appropriate competencies in the field of interpreting and analysing biological data at the beginning of the study. The generated findings were used as a baseline in determining the utility of the AI-based instruction intervention applied at the onset of the experiment.

Performance of Experimental and Control Groups. To assess the efficiency of artificial intelligence tools, experimental and control groupings were comprised of the subjects. Both groups carried out the same diagnostic assessment before the intervention. The results indicated similar levels of data interpretation skills among the participants, which offered a solid grounding to compare the learning. In the experimental group formative task, the experimental group had AI tools (e.g. ChatGPT, Gemini, Claude, Copilot and Napkin AI). The control remained instructed in standard ways. After the intervention, completion of post-test in both groups involved data analysis, data interpretation, conclusion drawing, and interpretation of the visualization. There was significant improvement in both groups. However, the experimental group made clear improvements. In the experimental group, students performed better when analyzed biological data, found patterns, and explained research findings. They also exhibited improvements in their confidence when engaging with graphs, charts, and visualized datasets. In comparison, only moderate improvement was observed in the control group. These results indicate that AI-induced learning tasks lead to a favourable growth of data interpretation skills of the future biology teachers.

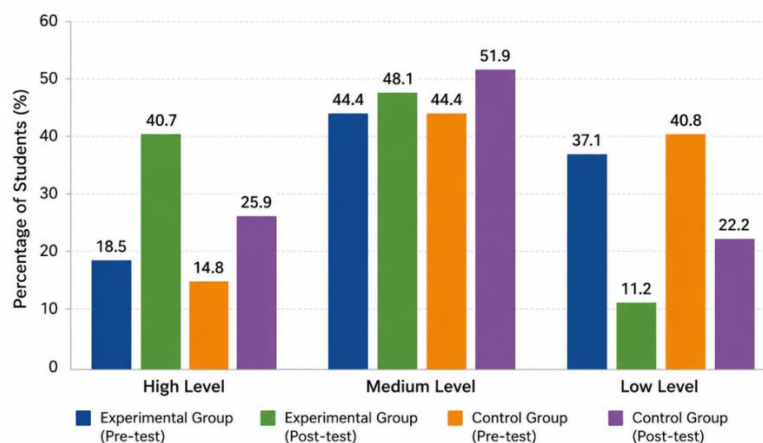


Figure 2. Analysis of Data Interpretation Skills between Experimental and Control Groups before and after intervention

The authors developed this guide. The distribution among participants across proficiency levels is shown in Table 2.

Table 2 – Results of the Experimental and Control Groups

Group	High (%)	Medium (%)	Low (%)
Experimental Group (Pre-test)	18.5	44.4	37.1
Experimental Group (Post-test)	40.7	48.1	11.2
Control Group (Pre-test)	14.8	44.4	40.8
Control Group (Post-test)	25.9	51.9	22.2

As illustrated in Table 2 the percentage of high level students in the experimental group increased from 18.5% to 40.7%. Moreover, the proportion of students at the low level dropped from 37.1% to 11.2%. The study results show a general improvement in these skills. The control group also witnessed positive changes, but they were less obvious. The result has more generally shown that artificial intelligence elements in learning processes contributed to a higher degree of improvement in data interpretation skills.

Results following the Formative Phase. This formative stage was focused on improving students' data interpretation skills, harnessing the uses of artificial intelligence tools. Meanwhile, participants interacted with biological datasets, graphs, tables, and graphics with ChatGPT, Gemini, Claude, Copilot, and Napkin AI. There was a positive change after the intervention. Students exhibited greater confidence in the processing of biological data and in reading research results. Such knowledge could be seen by their increased understanding of data patterns that were helpful in articulating biological relations. Improvement in data interpretation and visualization tasks was the most significant. Graphs, charts and diagrams contributed better performance in participants' data. Their statements became more precise, more supported by evidence. In general, the results showed that the AI-supported learning activities have contributed to the development of the data interpretation abilities in prospective biology teachers.

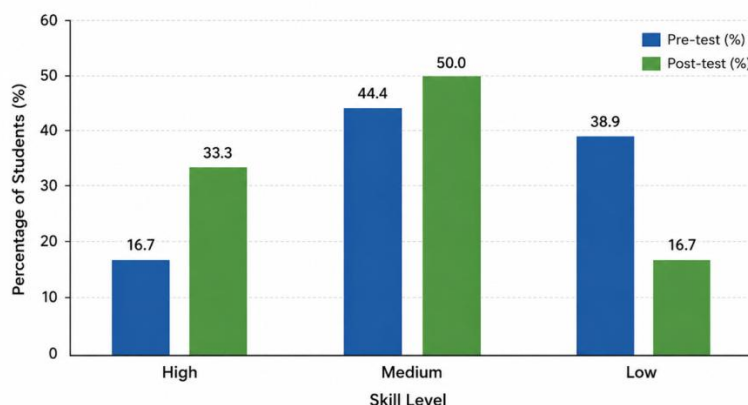


Figure 3. Changes in Data Interpretation Skill Levels Before and After the Formative Stage

The results of the formative stage are presented in Table 3.

Table 3. Changes in Data Interpretation Skill Levels Following the Intervention

Level	Pre-test (%)	Post-test (%)
 High	16.7	33.3
 Medium	44.4	50.0
 Low	38.9	16.7

Table 3 shows the results of the formative stage. It contrasts data interpretation skill levels after the intervention. The proportion of high-level students increased from 16.7% to 33.3%, as depicted in Table 3. On the one hand, the low level of students dropped from 38.9% to 16.7%. For the medium level, the increase was also modest, from 44.4% to 50.0%. Findings were that the introduction of artificial intelligence assisted students enhance their analytical, interpretation and communication skills regarding biological phenomena.

Comparative Study of Proficiency level changes. Comparison of pre- and post-test scores indicated improvement for all levels of proficiency. The largest change was the reduction among the low students and an increase amongst medium/high learners. This phenomenon implies that the intervention fostered skills for data interpretation skills.

Low Level. When the study was initiated, 38.9% of participants were classified as being at the low level. After the intervention, it reduced to 16.7%. Students have shown improved skills in scrutinizing biological data and interpreting research reports. They also gained confidence when engaged with scientific data and visual materials.

Medium Level. The percentage of students at a medium level increased from 44.4% to 50.0%. The growth rate was modest but significant. The participants showed better knowledge of biological information and could recognize patterns and the ability to explain their findings and outcomes.

High Level. At the highest level, there was a larger rise. The proportion of these students increased from 16.7% to 33.3%. They showed more appropriate analytical thinking, improved data interpretation skills, and higher level of evidence-based reasoning. They also did better on graphs, charts, and visualized datasets.

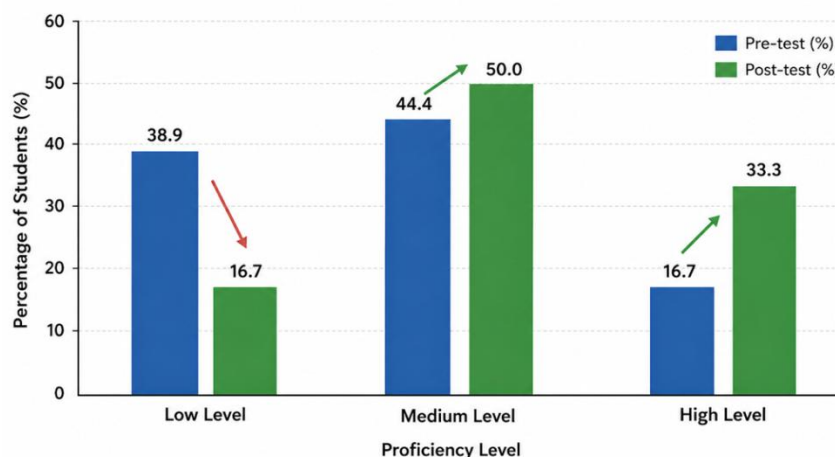


Figure 4. Change in Students' Proficiency Before and After Intervention

The results represent a clear trend from lower to higher levels of proficiency. The increase in the high-level category and decrease in the low-level category suggests a beneficial effect of AI-enabled learning activities on the data interpretation skills development of biology teachers in the future.

The findings were presented in tables and figures to facilitate comparison. Quantitative data is summarized in Tables 1–3, Figures 1–4 demonstrate differences in interpretation proficiency across the experiment. Statistical and visual analyses showed a positive trend. The percentage of learners from the lower levels went down, while the rate of the learners at the medium and high levels increased. Taken together, the results in Tables 1–3 and Figures 1–4 present undeniable proof that the utilisation of AI tools facilitated the education of the developing understanding of data interpretation for prospective future biology teachers.

Discussion. Interpretation of the Findings. The outcomes indicate that embedding artificial intelligence aids in the learning process significantly helped build the knowledge of data interpretation of the prospects of future teachers of biology. Students obtained successful knowledge of biological information, the ability to analyse and interpret datasets, and use evidence for their reasoning. One such effect that was apparent was the decrease in the number of students at the low level for learning and the increase of the medium proficiency as well as the high levels. This shift indicates that the AI-enhanced activities offered more time to practice, be self-directed and critically reflect. The results also point to the relevance of data-focused learning for biology education. Students built the skills required to analyze and interpret material through regular interactions with datasets, visualisations, and AI-generated cues. Ability of Artificial Intelligence Tools to Perform Well. The research also verifies that the application of AI tools can support learning effectively in biology education. ChatGPT, Gemini, Claude, Copilot and Napkin AI were helpful for students to delve into biological information, data and explanation. Benefits Several benefits were brought into focus during the experiment. Students were given responsive feedback, they were able to access more information, and their ideas were more directed. These opportunities for active learning promoted deep learning and engagement in scientific content. These tools were particularly helpful visualization tools. Diagrams, concept maps and infographics supported students with better understanding of complex biological relationships to research findings and better understanding of how these relationships operate. Therefore, AI technologies were transformed into sources not only of information but also of high-level thinking skills. Comparison to Previous Investigations. The findings from this study are consistent with previous research on artificial

intelligence for educational purposes. Such learning can be enhanced by AI-supported methods to support critical thinking, problem solving, and academic performance as previously showed. Similar trends in the previous study were found. The students who worked with AI tools reported better performance at data interpretation tasks and more confidence when manipulating biological data. Despite many studies investigating general learning outcomes, the study suggests that AI tools can support the development of data interpretation skills in biology teacher education. This broadens our awareness of the pedagogical utility of artificial intelligence in higher education practices. Study's scientific and practical significance. The scientific implications of this work are the empirical evidence on the purpose of artificial intelligence to promote teachers' competences required in data interpretation in future biology teachers, which will inform teaching of this teaching subject. The results add to the increasing volume of findings on educational digitalization and AI-assisted learning. The practical consequences are just as relevant. The recommended approach may be used in university, teacher education, and on digital learning. These AI applications can help with data analysis, scientific reasoning, and evidence-based governance. The study further provides methodological advice on integrating artificial intelligence into biology education. The recommendations may help educators to build more interactive and data-based learning experiences. Limitations of the Study. There are several limitations that must be regarded. There are a total of 54 first-year master's students from a single university participated in the paper. Thus caution must be used in extrapolating findings to wider populations. The intervention also took place over relatively limited time. Further investigation with longer practice time frame might yield more information on long term impact on AI-enabled learning. Furthermore, the research was concentrated on the data interpreting skill. The other competencies: creativity, collaboration (or collaborative project-type work), and research design abilities were beyond. Despite these challenges, the results demonstrate the educational potential of artificial intelligence tools and provide a solid basis for future research in biology teacher education.

Conclusions. Summary of the Findings. Through this study, the author examines how artificial intelligence tools foster data interpretation abilities in future biology teachers. The results displayed favorable changes in all measured aspects such as data analysis, interpretation, conclusion drawing, and visualization interpretation. Learners were more confident when working with biological data. They were able to do a better job at spotting trends and finding patterns, making sense of results, and drawing evidence-based conclusions. Enhanced reading of graphs, charts, and other visual resources was also recorded. In short, studies have shown that AI tools can augment and supplement the learning experience – while also helping to build competencies that are critical in today's biology classroom. This experiment proved the hypothesis that the study was accurate in confirming the findings. We assumed that systematically applying artificial intelligence tools would help future biology teachers to improve data interpretation skills. The results lend credence to this assumption. The participants who were involved in the AI-enabled learning exercise had better results for analyzing and interpreting biological messages. They also became more confident expressing scientific results and interacting with research findings. These results show that the use of artificial intelligence can be considered as a promising method to enhance teacher teaching skills in data interpretation. Suggestions for Further Research. This study leaves a number of avenues for future research. Similar research might be carried out with larger samples of participants and from other universities. This would create a wider perspective on how good AI-supported learning is. Future research could also investigate the enduring influence of AI on professional competence development. Longer-term interventions might also indicate whether the changes observed in recent studies hold over time. Another fruitful avenue of investigation includes how AI tools are impacting critical thinking, scientific exploration, creativity, and research skills. Comparative research on various AI platforms would be useful to establish the best path to integrating AI-driven learning approaches for biology teachers in their instruction. While AI innovation continues, its educational application should be further explored. More comprehensive research will assist teachers in utilizing these tools and also prepare educators for data-driven schools to provide better education for learners of tomorrow.

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FTAXP 14.25.09

<https://doi.org/10.51889/2959-5762.2026.91.3.015>

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ЖОҒАРЫ ОҚУ ОРНЫ СТУДЕНТТЕРІНЕ БЕЙОРГАНИКАЛЫҚ ХИМИЯНЫ ОҚЫТУДА WEB 2.0 ҚҰРАЛДАРЫН ҚОЛДАНУДЫҢ АРТЫҚШЫЛЫҚТАРЫ

Аңдатпа

Бейорганикалық химияны оқытуда Web 2.0 құралдарын қолдану қазіргі білім беру жүйесіндегі заманауи технологияларды тиімді пайдаланудың бір жолы болып табылады. Бұл мақалада аталған құралдарды оқу үдерісіне енгізудің маңыздылығы мен артықшылықтары қарастырылады. Ақпараттық-коммуникациялық технологиялардың жедел дамуы білім алушылардың оқуға деген ынтасын арттыруға, оқыту сапасын жақсартуға және пәнге деген қызығушылығын күшейтуге жаңа мүмкіндіктер ұсынады. Web 2.0 құралдары арқылы оқушылардың өздігінен білім алуына, шығармашылық қабілеттерін дамытуына және танымдық белсенділігінің артуына жол ашылады. Мақаланың мақсаты – бейорганикалық химияны оқытуда Web 2.0 құралдарын қолданудың тиімді жолдарын анықтап, олардың оқу сапасына тигізетін оң әсерін дәлелдеу. Зерттеу барысында салыстырмалы талдау, бақылау, сауалнама және тәжірибелік сабақтар әдістері қолданылды. Нәтижесінде Web 2.0 құралдарын қолдану оқушылардың пәнге деген қызығушылығын арттырып, білім сапасын жоғарылататыны анықталды. Сонымен қатар, мұндай әдістер оқушылардың ойлау, талдау, топпен жұмыс жасау және өз ойын еркін жеткізу дағдыларын дамытуға ықпал ететіні байқалды. Мысалы, Padlet, Kahoot, Google Forms, Quizlet, Wordwall сияқты сервистерді пайдалану арқылы сабақ мазмұнын түрлендіріп, оны интерактивті әрі қызықты етіп өткізуге болады. Қорытындылай келе, бейорганикалық химияны оқытуда Web 2.0 құралдарын қолдану – заманауи білім берудің тиімді тетігі. Ол мұғалім мен оқушы арасындағы байланысты нығайтып қана қоймай, оқытудың сапасы мен нәтижелілігін арттыруға мүмкіндік береді.