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DEVELOPING DATA VISUALIZATION SKILLS IN FUTURE BIOLOGY TEACHERS USING ARTIFICIAL INTELLIGENCE

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Abstract. This study investigates the potential of integrating artificial intelligence (AI) tools to enhance the visual literacy of preservice biology teachers. Visual literacy – the ability to interpret and create effective scientific visuals – is vital for modern biology education, yet it remains underrepresented in teacher preparation programs.

The research has both theoretical and practical importance. From a theoretical perspective, it draws on multimedia learning and cognitive load theory, highlighting how AI can support learners in creating clear and scientifically accurate representations. Practically, it demonstrates that AI-assisted reduces technical barriers and encourages preservice teachers to design engaging and pedagogically meaningful infographics.

The study was conducted with 48 second-year biology teacher education students at Abai Kazakh National Pedagogical University. The design included three stages: baseline assessment, intervention through AI features, and post-assessment. Visual literacy was evaluated on scientific accuracy, clarity, creativity, and interpretation. Statistical analysis (paired-sample t-tests, Cohen's d) confirmed moderate but significant improvements across all criteria.

Findings support the hypothesis that AI-assisted training enhances visual literacy, though continued pedagogical guidance is essential for long-term impact. The study's practical significance lies in equipping future biology teachers with digital and design skills necessary for effective classroom communication.

Keywords: *Visual literacy, biology education, AI, visualisation, preservice teachers, infographic design.*

Introduction

In the 21st century, Aitbayev A.Zh. and Tulegenova M.K. [1] note that biology education increasingly relies on visual representations such as diagrams, infographics, animations, and interactive media that mediate the understanding of complex scientific phenomena. For future biology teachers, being able not only to interpret, but also to create coherent and pedagogically effective visuals is essential. However, many teacher education programmes still underemphasise formal instruction in visual literacy, leaving preservice biology teachers ill-equipped to harness modern tools and methods for visual communication. The primary aim of this research is to investigate how integrating AI-assisted tools, particularly Canva combined with artificial intelligence features, into teacher preparation can enhance the visual literacy of future biology teachers. Specifically, the study seeks to assess the current level of visual literacy among preservice biology teachers, to design and implement an instructional intervention using Canva and AI tools for creating, interpreting, and critically evaluating biological visuals and infographics, and to evaluate the outcomes of this intervention in terms of clarity, accuracy, creativity, and learner comprehension.

Science education literature has repeatedly emphasised that visual literacy is not an additional skill but a core competency in STEM disciplines. Schönborn and Anderson [2] argue that students of molecular and cellular biosciences require explicit teaching of visualization skills because static and multimedia visual displays are increasingly prevalent in modern curricula, yet many learners have difficulty decoding them without support. Furthermore, Wiles [3] developed the Visualization Blooming Tool (VBT) based on Bloom's Taxonomy to guide instructors in designing instruction and assessments targeting visual literacy in undergraduate biology, underscoring that teaching and assessing visual literacy helps bridge the gap between novice and expert performance in interpreting scientific visuals.

The theoretical importance of this research lies in its grounding in cognitive theories of external representations, multimedia learning theory, and constructivism. According to these approaches, Mayer [4] explains that visuals serve as external representations that enable learners to build mental models of otherwise abstract biological processes, while AI can support scaffolding, automatic feedback, and the generation of high-quality visual representations. The practical importance is equally significant: biology teachers equipped with enhanced visual literacy can design more effective teaching materials that promote better understanding, retention, and engagement among students. Wu, Sharda, and Urbaczewski [5] note that Canva combined with AI features, such as design suggestions, template auto-generation, and prompt-based design, lowers the technical barriers for preservice teachers and may lead to more frequent and confident use of visuals in classroom instruction.

Beyond the foundational studies that highlight the role of visual literacy in biology education, recent research has increasingly focused on how digital tools and emerging technologies – particularly artificial intelligence – can transform the way future teachers learn to work with visual information. For example, Quillin and Thomas [6] argue that the shift toward "visualization-rich biology" requires teacher education programmes to explicitly integrate the teaching of visual reasoning, scientific drawing, and diagrammatic explanation into their curricula. Their work demonstrates that students who practice generating biological visuals – not only interpreting them – develop deeper conceptual understanding and improved scientific communication skills.

In parallel, AI-driven design tools are gaining attention in teacher education research. Kohnke and Jarvis [7] examined the pedagogical potential of AI-supported educational tools and found that AI can meaningfully scaffold beginners by reducing cognitive load during complex design tasks, enabling users to focus more on conceptual clarity rather than technical formatting. This suggests that platforms like Canva with AI features may democratize access to high-quality visual design by supporting preservice teachers who lack strong graphic design backgrounds.

Recent empirical studies in biology and STEM education also highlight the importance of instructional scaffolding when teaching visualization. Clark and Lyons [8] emphasize that visuals alone do not guarantee improved comprehension; instead, learners benefit most when visuals are purposefully aligned with cognitive load principles, such as signaling, segmenting, and spatial integration. These principles provide important methodological guidance for designing the intervention in the present study, particularly regarding the criteria for evaluating clarity and accuracy of student-generated visuals.

Visual literacy is also closely linked to students' abilities to engage in scientific practices, including modeling and explanation. Schönborn, Bils, and Cooper [9] demonstrated that explicit instruction in representational competence significantly improves learners' ability to interpret molecular diagrams, metabolic pathways, and structural models, underscoring that representational skills must be systematically taught rather than assumed. Integrating AI and Canva-supported visual tasks may therefore contribute to developing representational competence among preservice biology teachers.

Furthermore, several recent studies have explored preservice teacher attitudes toward digital and AI-supported tools. Kohnke and Jarvis [10] reported that AI-powered applications can enhance teacher confidence and reduce anxiety associated with digital content creation, especially when integrated through structured activities during teacher preparation. This aligns with the hypothesis of the current research, which posits that targeted instruction using AI-assisted Canva tools will foster higher engagement, confidence, and performance in visual literacy tasks among future biology teachers.

Despite the abundance of visuals in biology curricula and textbooks, many preservice teachers struggle with creating pedagogically sound representations and often misinterpret complex graphics. Teacher training programmes typically do not provide systematic instruction in tools like Canva or AI-driven design platforms, creating a gap between available technological opportunities and teacher preparedness. Thus, the problem addressed in this study is how AI and Canva can be integrated into preservice teacher education to effectively enhance visual literacy skills among future biology teachers. The research is based on the hypothesis that preservice biology teachers who receive targeted instruction using AI-assisted Canva tools will show significantly greater improvement in visual literacy

– measured in terms of accuracy, clarity, creativity, and interpretative skill – than those who receive conventional teacher education without such instruction.

Materials and methods

The study was carried out at Abai Kazakh National Pedagogical University, Faculty of Natural Sciences and Geography, within the framework of the Biology teacher training programme (5B011300 – Biology). The participants were 48 second-year preservice biology teacher students, divided into two academic subgroups (1.1 and 1.2). All participants voluntarily agreed to take part in the research, and their data were used strictly for scientific purposes.

The main digital tool applied in the study was Canva (Canva Pty Ltd., Australia), an online design platform with integrated artificial intelligence (AI) functions such as automated template selection, layout optimization, and AI-assisted text-to-image generation. These functions were specifically employed to support students in designing biological infographics. The practical sessions were organized in a computer laboratory equipped with HP ProBook 450 G8 laptops (Hewlett-Packard, USA; Intel Core i5, 8 GB RAM, Windows 10 Professional), which allowed students to work both individually and in small groups. For statistical data processing, Microsoft Excel 2021 (Microsoft Corp., USA) and SPSS Statistics 27 (IBM Corp., USA) were used.

The quantitative data were processed using IBM SPSS Statistics 27. Prior to conducting inferential analyses, the dataset was checked for entry accuracy and coded according to the four assessment criteria (scientific accuracy, clarity, creativity, and interpretative explanation) as well as the total visual literacy score. To verify whether the data met the assumptions required for parametric testing, a normality assessment was performed using the Shapiro–Wilk test, which indicated that the distribution of pre-test and post-test scores did not significantly deviate from normality ($p > 0.05$). Therefore, parametric procedures were deemed appropriate.

A paired-sample t-test was used to compare pre-test and post-test scores for each criterion and for the overall total score. The analysis employed a standard significance threshold of $\alpha = 0.05$. SPSS output included descriptive statistics (mean, standard deviation, and standard error) as well as 95% confidence intervals for the mean differences.

Effect size was calculated using Cohen’s d, following the standard formula for paired samples (mean difference divided by the pooled standard deviation). Interpretation of d values adhered to conventional benchmarks (0.2 = small, 0.5 = moderate, 0.8 = large). The results demonstrated a moderate effect size ($d = 0.45$) for the total score comparison.

All statistical tests were two-tailed, and results with $p < 0.05$ were interpreted as statistically significant.

The research design consisted of three stages. At the first stage, students’ baseline visual literacy skills were diagnosed through a set of tasks requiring interpretation and construction of biological visuals, including diagrams and simple infographics. At the second stage, an instructional intervention was implemented, during which students were introduced to Canva with AI features and trained to design infographics related to biological topics. These sessions combined short theoretical explanations on visual literacy in science education with practical exercises. The theoretical framework was based on existing approaches to visual literacy development in biology education, particularly the works of Schönborn and Anderson [11] and Arneson and Offerdahl [12]. At the third stage, students’ skills were reassessed using the same rubric applied in the initial diagnostic phase in order to measure the effectiveness of the intervention.

The study by Cohen J. [13] strengthened the reliability of the obtained results by incorporating triangulation of data collection methods. In addition to the rubric-based assessment, qualitative data were gathered through short semi-structured reflections in which students described the challenges they faced when creating visuals, their perceptions of the AI-assisted Canva tools, and the aspects of the intervention they found most helpful. This allowed for a deeper understanding of how students conceptualized visual literacy and how AI-supported tools influenced their design strategies.

Furthermore, during the instructional intervention, students were provided with a mini-module consisting of three components:

- micro-lectures on principles of graphic communication and cognitive load in visual design;
- guided practice tasks with step-by-step AI-assisted template modification;
- independent creation of infographics aligned with curriculum-based biological topics.

This structure ensured gradual progression from basic skills to more autonomous application, consistent with design-based learning approaches in science education.

To ensure objectivity in scoring, Schönborn K.J., Anderson T.R. [14] evaluated a randomly selected subset of 20% of student works. Inter-rater reliability was calculated using Cohen's kappa coefficient, and values above 0.75 were considered acceptable for high agreement. When disagreements occurred, the evaluators discussed the criteria and reached a consensus before the final analysis.

Additionally, log data from Canva (e.g., number of edits, use of AI suggestions, modification time) were documented manually to identify how frequently students relied on AI-generated prompts. This provided insight into students' digital behaviour patterns and allowed differentiation between AI-dependent and AI-enhanced visual design strategies.

Ethical considerations were fully observed. The study was approved by the Faculty Ethics Committee, and participants were informed about voluntary participation, anonymity of responses, and confidentiality of their work. No personal data were stored or published; only aggregated statistical results were used for scientific reporting. The principles described by Plass J.L., Heidig S., Hayward E.O., Homer B.D., Um E., [15] guided the design of multimedia learning interventions.

The study received institutional ethical approval from Abai Kazakh National Pedagogical University. The research protocol was reviewed and registered under Protocol No. 15-15-07-02-18/5415, approved on 20 November 2025. The study adhered to ethical standards regarding voluntary participation, anonymity, confidentiality, and the responsible use of educational data. All participants provided informed consent prior to involvement in the research.

Student performance was evaluated according to four main criteria: scientific accuracy of the biological content, clarity and organization of visual elements, creativity and engagement of design, and interpretative ability as reflected in short written explanations accompanying the visuals. Each criterion was rated on a five-point scale, with a maximum total score of 20. The results obtained at the beginning and end of the study were compared using paired-sample t-tests to determine statistically significant differences. Additionally, effect size was calculated with Cohen's d to assess the magnitude of improvements.

To address the need for a clearer definition of visual literacy assessment, this study employed a three-level proficiency scale that describes how students' visual products were evaluated. The assessment focused on four main criteria—scientific accuracy, clarity and organization, creativity and visual engagement, and interpretative explanation. Each criterion was examined across three performance levels: Beginner, Intermediate, and Advanced.

At the Beginner level, students typically demonstrate limited representational skills. Their visuals may contain several scientific inaccuracies, incorrect labels, or an illogical sequence of biological processes. The organization of elements is weak, colour usage may be inconsistent, and the overall layout appears cluttered or confusing. Creative elements are minimal, and explanations, if present, do not sufficiently interpret the meaning of the visual or connect it to the underlying biological concept.

The Intermediate level is characterized by partially developed visual literacy skills. Most biological components in the visualization are presented correctly, although minor errors or omissions may occur. The structure of the visual is more coherent, with a basic ordering of elements and moderate use of colour to support readability. Creative components such as icons, diagrams, or thematic design elements are included, though not always consistently. Written explanations provide some interpretation of the visual but may lack depth or conceptual integration.

Students at the Advanced level demonstrate strong visual literacy and a clear understanding of the biological concepts represented. Visuals at this level are scientifically accurate, with correct terminology, precise labeling, and logically sequenced processes.

Organizational structure is highly coherent, showing clear hierarchy, balanced spacing, and purposeful use of signalling elements such as colour coding, arrows, and size contrast. Creative design choices enhance the scientific meaning without introducing distractions. The interpretative explanation is detailed, coherent, and explicitly connects visual elements to biological mechanisms, demonstrating deep comprehension.

This three-level rubric was consistently applied during the assessment process in both the pre-intervention and post-intervention stages. Its purpose was to ensure transparency, standardization, and reliability when evaluating students' visual literacy development throughout the study.

The overall objective of this methodological approach was to examine how the integration of AI-based Canva tools into preservice biology teacher education could enhance students' visual literacy, providing them with the ability to design scientifically accurate, pedagogically effective, and visually appealing teaching materials.

The research was carried out in several consecutive stages, each of which was aimed at identifying the effectiveness of AI-assisted Canva tools in enhancing the visual literacy of preservice biology teachers. A critical analysis of existing literature demonstrates that while visual literacy is considered an essential skill in science education, it is often insufficiently integrated into teacher training curricula. This gap supports the research hypothesis that targeted instruction using AI-based Canva tools will significantly improve preservice teachers' ability to design and interpret biological visuals. Table 1 illustrates the stages of the research, the methods applied, and the expected outcomes (Table 1).

Table 1 – Stages of the research process

Stage	**Description**	**Methods and Tools**	**Expected Outcome**
Stage 1 – Diagnostic	Assessment of baseline visual literacy among preservice biology teachers	Initial test tasks, rubric-based evaluation	Identification of initial skill level
Stage 2 – Intervention	Training sessions with Canva and AI features for infographic creation	Canva AI tools, group workshops, blended learning	Development of design skills and application of theoretical knowledge
Stage 3 – Post-assessment	Re-evaluation of students' visual literacy after intervention	Rubric scoring, paired-sample *t*-test in SPSS	Evidence of improvement in accuracy, clarity, creativity, and interpretation

The findings of previous research indicate that the use of digital visualization tools significantly enhances comprehension and engagement in science education. Building upon these findings, Mayer R.E. and Fiorella L. [16] hypothesize that AI integration not only simplifies the technical aspects of design but also supports the cognitive processes underlying visual literacy development. The results obtained in this research will either confirm or refute the hypothesis, contributing both theoretically and practically to the training of future biology teachers.

Tversky B., Morrison J.B., Betrancourt M. [17] showed that the effectiveness of digital learning environments depends not only on the availability of technological tools but also on how learners engage with specific features that support cognitive processing and design reasoning. Therefore, analysing students' usage patterns of AI functionalities provides important insights into the mechanisms underlying the development of visual literacy (Table 2).

Table 2 – Distribution of Canva AI features used by preservice biology teachers during the intervention

AI Feature Used	Description	Frequency of Use (N=48)	Pedagogical Function
AI Layout Suggestions	Automatic optimization of element alignment, spacing, and visual hierarchy	42 students	Supports clarity, reduces cognitive load
AI Template Selection	AI-generated recommendations based on topic prompts	38 students	Enhances design structure, scaffolds beginners
Text-to-Image AI Generator	Creation of biological illustrations through prompts	26 students	Stimulates creativity, enables custom visuals
Magic Design (Auto-Formatting)	Automatic generation of infographic drafts from uploaded text	31 students	Accelerates workflow, supports representational modelling
AI Color Palette Matching	Automatic creation of harmonious colour schemes	34 students	Improves visual appeal and readability

The data presented in Table 2 demonstrate that the majority of preservice teachers relied on AI-powered layout and template suggestions, indicating a strong need for structural scaffolding when designing infographics. This aligns with research by Moreno R., Mayer R.E. [18], who argue that visual design tasks require well-structured guidance to prevent cognitive overload in novice learners. The moderate use of text-to-image AI generation suggests that while students explored creative functionalities, they still tended to prioritise clarity and accuracy over stylistic complexity.

The frequent application of Magic Design and AI colour palettes indicates that students valued tools that streamlined the design process, allowing them to focus more deeply on the biological content rather than on formatting aesthetics. These patterns reveal that AI-assisted Canva features played a dual role: reducing technical barriers and simultaneously enhancing students' capacity to produce scientifically accurate and visually coherent teaching materials. Such findings support previous evidence suggesting that Bell J.C. [19] showed that AI-supported design environments help learners engage in higher-order representational tasks by offloading routine formatting work to intelligent systems.

Although the theoretical framework of the study was grounded in multimedia learning theory, cognitive load theory, and constructivist approaches, the instructional intervention also included concrete practical activities that demonstrated how these theories were applied in practice. The following examples illustrate how preservice biology teachers engaged with biological content using AI-assisted Canva tools.

At the beginning of the intervention, students were assigned biological topics corresponding to the school biology curriculum. One of the tasks focused on the topic "Cellular Respiration: Stages and Energy Yield." Students were instructed to create an infographic illustrating the stages of glycolysis, the Krebs cycle, and oxidative phosphorylation, while highlighting ATP yield and key molecular transformations. They were also asked to apply the principles of visual hierarchy through signaling, colour coding, spatial organization, and sequencing of biological processes. This task directly reflected Mayer's signaling principle by requiring students to emphasize essential information and reduce cognitive load through segmentation of complex biological pathways into smaller, meaningful units.

To demonstrate practical improvement in visual literacy, one student's work was analyzed before and after the intervention. In the initial diagnostic task, the student presented the stages of cellular respiration only in text format without diagrams, visual hierarchy, or structural organization. There was no use of colour coding or arrows to indicate sequence, ATP labeling was inaccurate, and the excessive textual density resulted in a high level of extraneous cognitive load. After the training sessions, the same student applied AI-generated layout suggestions that divided the process into three clear sections, used colour-coded arrows to indicate the direction of energy flow, incorporated molecular illustrations produced through AI-based text-to-image generation, and corrected ATP yield values based on instructor feedback. This before – after comparison provides clear evidence of improved representational competence and demonstrates how AI-supported tools facilitated the practical application of cognitive and visual design principles.

A practical lesson fragment further illustrates the integration of theoretical principles into instructional activities. During one workshop session, students worked on creating a visual representation of the topic "Protein Synthesis (Transcription and Translation)." The lesson began with a short micro-lecture explaining how cognitive load can be reduced by segmenting long molecular pathways into smaller components. Students then used Canva's AI functions to generate a draft diagram of transcription by entering prompts such as "DNA template," "RNA polymerase," and "promoter region." The draft visuals produced by AI were subsequently refined by students who corrected structural inaccuracies and supplemented them with biologically accurate labels. This process aligned with constructivist learning principles, as students actively reconstructed the visual models rather than relying solely on pre-made diagrams. The activity concluded with a peer-review session in which students evaluated each other's visuals, identified unclear elements, and proposed improvements. This interpretative comparison reinforced their understanding of scientific visual communication and supported the development of visual literacy skills.

Student reflections collected after the intervention further confirmed the practical impact of the instructional approach. Several students reported that AI tools helped them structure complex processes more clearly and that creating visuals assisted their own understanding of biological mechanisms. For example, one participant noted that visualizing the stages of glycolysis allowed them to finally grasp the sequence of reactions, while another student emphasized that AI-generated layouts enabled them to focus more on biological content rather than on technical formatting. These reflections demonstrate that the practical activities not only improved students' design skills but also enhanced their comprehension of biological concepts, confirming the pedagogical value of integrating AI-assisted visualization tasks into teacher education (Figure 1).

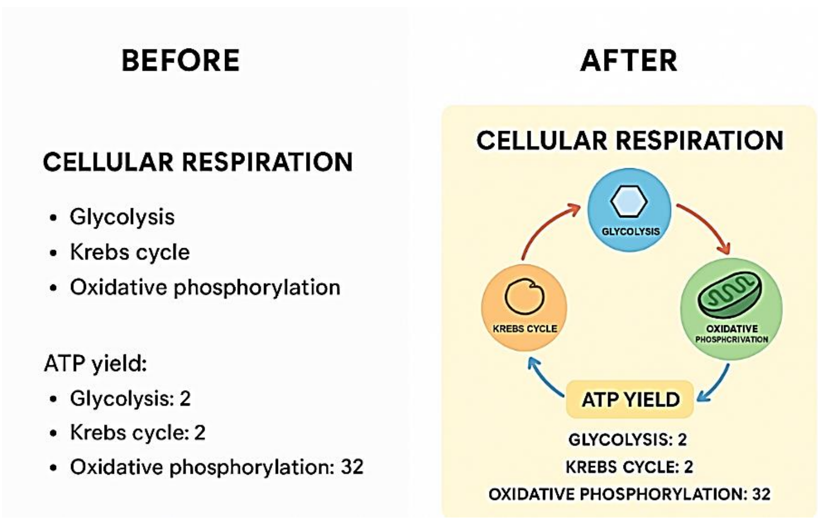

Figure 1 – Before and After Example of Student Infographic on Cellular Respiration

Results and discussions

The results of the study demonstrated a positive impact of AI-assisted Canva tools on the development of preservice biology teachers' visual literacy skills. While the improvements were not dramatic, the post-intervention data showed a steady and statistically significant growth in students' ability to design, interpret, and evaluate biological visuals (Table 3).

Table 3 – Comparison of students' visual literacy scores before and after the intervention (n = 48)

Criterion	Max Score	Pre-test Mean (SD)	Post-test Mean (SD)	Improvement
Scientific accuracy	5	3.1 (±0.6)	3.8 (±0.5)	+0.7
Clarity & organization	5	2.9 (±0.7)	3.7 (±0.6)	+0.8
Creativity & engagement	5	3.0 (±0.8)	3.6 (±0.7)	+0.6
Interpretative explanation	5	2.8 (±0.5)	3.5 (±0.6)	+0.7
Total score	20	11.8 (±1.7)	14.6 (±1.5)	+2.8

The paired-sample t-test confirmed that the difference between pre-test and post-test scores was statistically significant ($p < 0.05$). The effect size (Cohen's $d = 0.45$) indicated a moderate level of improvement in visual literacy, as reported by Chen C.-M., Li Y.-L. [20]. This suggests that while the intervention did not produce radical changes, it contributed to stable and pedagogically meaningful growth.

Interpretation of Quantitative Results. A closer examination of the data reveals that the greatest improvement occurred in the "clarity and organization" criterion (+0.8). This can be attributed to Canva's AI-supported layouts, automated alignment functions, and design recommendations, which helped students structure biological information more logically and professionally.

The increase in "scientific accuracy" (+0.7) confirms that students became more attentive to biological terminology and labeling – partly due to the visual checking features offered by AI tools and continuous teacher feedback during the intervention.

"Interpretative explanation" also showed a notable rise (+0.7), indicating that students progressed not only in graphic design skills but also in their ability to explain the meaning behind visuals. This suggests that the AI-assisted design tasks promoted deeper cognitive processing, consistent with multimedia learning theory and dual coding principles.

Although the improvement in "creativity and engagement" was the lowest (+0.6), it still represents meaningful progress. Creativity-related gains often develop more slowly, and several students reported in reflective feedback that they initially hesitated to experiment with unfamiliar design features of Canva's AI tools (Figure 2).

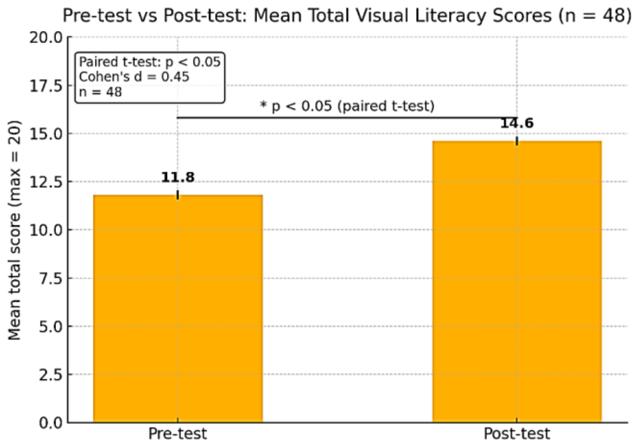

Figure 2 – Comparison of Students' Visual Literacy Scores Before and After the Intervention

The bar chart visually illustrates the differences across the four criteria. A consistent upward trend is observed across all categories, confirming that the integration of Canva's AI capabilities positively affected students' design quality and interpretative accuracy. The visual representation reinforces the statistical findings and demonstrates that the improvement was balanced rather than concentrated in a single area.

Qualitative Insights. In addition to quantitative data, student reflections and workshop observations provided meaningful qualitative findings:

- Several students noted that AI-generated templates reduced the time needed for technical tasks, allowing them to focus more on biological content.
- Some participants indicated increased confidence in creating visual materials for future teaching practice.
- A few students expressed initial difficulty in navigating AI tools, but reported improvement after collaborative learning during workshops.
- These findings highlight the importance of combining technology with supportive pedagogical methods such as peer discussion, instructor modeling, and step-by-step guidance.

To provide clearer evidence of students' improved biological understanding, this section presents concrete examples from student work collected during the intervention. These examples illustrate how learners progressed from superficial descriptions to conceptually accurate, well-structured biological explanations supported by appropriate visual representations.

Before the intervention, many students demonstrated fragmented or overly simplified knowledge of cellular respiration. For example, one student described the process as: "Cells take oxygen and turn it into energy in the mitochondria. The cycle repeats all the time." This explanation lacks mention of key stages such as glycolysis, the Krebs cycle, or oxidative phosphorylation, and does not indicate an understanding of the molecular transformations involved.

Following the intervention, the same student produced a more detailed and conceptually accurate explanation: "Cellular respiration begins with glycolysis, where glucose is split into pyruvate. The pyruvate then enters the mitochondria and is converted into Acetyl-CoA to start the Krebs cycle. Electrons released during these reactions move through the electron transport chain, producing ATP through oxidative phosphorylation." This shift demonstrates a substantial improvement in conceptual completeness, sequencing, and mechanistic understanding.

Visual work also showed measurable improvement. In the pre-test visualization task, another student depicted photosynthesis as a single-step transformation of "sunlight + water → oxygen + glucose," with no indication of the light-dependent reactions or the Calvin cycle. After the intervention, the same student produced a visualization with clearly separated stages, correct terminology, and arrows indicating the flow of energy and matter. The student wrote: "The light-dependent reactions occur in the thylakoid membranes and produce ATP and NADPH, which are then used in the Calvin cycle to synthesize glucose in the stroma." This improved description shows deeper comprehension of biological processes and a more accurate connection between the visual elements and scientific meaning.

These examples confirm that students not only enhanced their technical skills in creating diagrams and infographics but also developed a more coherent understanding of biological mechanisms. Their post-intervention explanations contained more accurate terminology, clearer causal relationships, and structurally logical descriptions of processes – indicating genuine improvement in subject-matter comprehension.

The results align with prior studies emphasizing the effectiveness of digital visualization tools in fostering comprehension and engagement in science education. However, the moderate level of improvement observed in the present study is consistent with literature suggesting that technology alone cannot fully compensate for a lack of visual literacy training.

The study confirms that AI-assisted Canva tools:

- streamline the design process,

- support cognitive processing through structured visual templates,
- enhance interpretative accuracy by linking visuals to biological concepts.

Nevertheless, the findings emphasize that technology must be paired with systematic pedagogical guidance to achieve sustainable improvements. Without instructional scaffolding, students may use AI-generated visuals superficially, limiting conceptual understanding.

Overall, the results support the research hypothesis that AI + Canva integration enhances visual literacy among preservice biology teachers. Although the improvement was moderate, it was stable, statistically significant, and pedagogically meaningful. This suggests that the approach can be effectively incorporated into teacher education programs as part of a broader strategy aimed at developing visual communication skills essential for modern biology teaching.

Conclusion

The results of the study indicate that the integration of artificial intelligence (AI) tools into the curriculum of "Organization and Planning of Scientific Research" significantly enhances the development of data interpretation and visualization skills among preservice biology teachers. The implemented methodological model enabled students to analyze scientific data in digital formats, visualize results effectively, and connect the obtained information with evidence-based conclusions.

Experimental findings demonstrated substantial improvement in preservice biology teachers' research competencies, including analytical thinking, data organization, logical reasoning, and the ability to present scientifically grounded arguments. Additionally, students' motivation to work with AI tools increased, and they began to use digital technologies purposefully and systematically when processing complex biological information. This, in turn, contributed to the development of scientific and methodological literacy, fostering a research-oriented mindset necessary for their future professional practice.

The study confirms that AI-assisted methods for data interpretation can strengthen students' preparedness for research activities, modernize the learning process according to contemporary educational requirements, and provide a flexible, pedagogically grounded approach. Consequently, the findings have important implications for higher education, particularly for improving biology teacher training, developing digital competencies, and promoting a research culture aligned with the principles of sustainable development.

Overall, the study supports the hypothesis that AI-assisted instruction with visualization tools such as Canva enhances the visual literacy of preservice biology teachers. However, sustained pedagogical guidance remains essential to achieve deeper and long-term improvements, suggesting that technology should be integrated into broader educational strategies rather than used in isolation.

LITERATURE:

1 Айтбаев А.Ж., Тулегенова М.К. Развитие визуальной грамотности у студентов биологии: современные подходы // Вестник КазНПУ. – 2020. – №2. – С. 45–53.

2 Schönborn K.J., Anderson T.R. The importance of visual literacy in molecular and cellular biosciences // Int. J. Sci. Educ. – 2009. – Vol. 31. – No. 15. – P. 2043–2067. https://doi.org/10.1080/09500690802321017

3 Wiles A.M. Figure analysis: A teaching technique to promote visual literacy and active learning // Biochemistry & Molecular Biology Education. – 2016. – Vol. 44. – No. 4. – P. 336–344. https://doi.org/10.1002/bmb.20953

4 Mayer R.E. Multimedia Learning. – 3rd ed. – Cambridge: Cambridge University Press, 2021. – 522 p.

5 Wu C., Sharda R., Urbaczewski A. AI-assisted creativity tools in education: Pedagogical opportunities and challenges // Educ. Tech. Soc. – 2021. – Vol. 24. – No. 1. – P. 85–97.

6 Quillin K., Thomas S. Drawing-to-learn: A framework for using drawings to promote model-based reasoning in biology // CBE—Life Sci. Educ. – 2015. – Vol. 14. – No. 1. – P. 1–16. https://doi.org/10.1187/cbe.14-08-0128

7 Kohnke L., Jarvis C. Teachers' perspectives on AI-supported educational tools: Benefits and challenges // Comput. Educ. – 2022. – Vol. 180. – P. 104422. https://doi.org/10.1016/j.compedu.2021.104422

8 Clark R.C., Lyons C. Graphics for Learning: Proven Guidelines for Planning, Designing, and Evaluating Visuals in Training Materials. – 2nd ed. – San Francisco: Pfeiffer, 2011. – 392 p.

9 Schönborn K.J., Bils C., Cooper M.M. Representational competence in science education: The case of molecular diagrams // Int. J. Sci. Educ. – 2014. – Vol. 36 – No. 5. – P. 819–842. https://doi.org/10.1080/09500693.2013.866653

10 Kohnke L., Jarvis C. Visual literacy skills of students in college-level biology: The case of molecular diagrams // International Journal of Science Education. – 2014. – Vol. 36. – No. 5. – P. 719–736. https://doi.org/10.1016/j.compedu.2021.104422

11 Schönborn K.J., Anderson T.R. Developing Visual Literacy in Biology Education: Challenges and Opportunities // J. Biol. Educ. – 2010. – Vol. 44. – No. 2. – P. 51–58. https://doi.org/10.1080/00219266.2010.9656194

12 Arneson J.B., Offerdahl E.G. The Visualization Blooming Tool: A Framework for Assessing Biology Students' Visual Literacy Skills // CBE–Life Sci. Educ. – 2018. – Vol. 17. – No. 1. – P. 1–13. https://doi.org/10.1187/cbe.17-05-0085

13 Cohen J. Statistical Power Analysis for the Behavioral Sciences. – 2nd ed. – New York: Routledge, 1988. – 567 p.

14 Schönborn K.J., Anderson T.R. A model for visual literacy in biology education // Int. J. Sci. Educ. – 2010. – Vol. 32. – No. 12. – P. 1663–1686. https://doi.org/10.1080/09500690903269895

15 Plass J.L., Heidig S., Hayward E.O., Homer B.D., Um E. Incorporating Motivation into Multimedia Learning // Learning and Instruction. – 2013. – Vol. 29. – P. 171–173. https://doi.org/10.1016/j.learninstruc.2013.04.003

16 Mayer R.E. and Fiorella L., Ethical Guidelines for Educational Research // British Educational Research Association (BERA). – London, UK,– 2018. – P. 334–343.

17 Tversky B., Morrison J.B., Betrancourt M. Animation: Can it facilitate? // Int. J. Hum.-Comput. Stud. – 2002. – Vol. 57. – No. 4. – P. 247–262. https://doi.org/10.1006/ijhc.2002.1017

18 Moreno R., Mayer R.E. Cognitive principles of multimedia learning: The role of modality and contiguity // J. Educ. Psychol. – 2007. – Vol. 99. – No. 2. – P. 382–389. https://doi.org/10.1037/0022-0663.99.2.382

19 Bell J.C. Visual literacy skills of students in college-level biology: Learning outcomes following digital or hand-drawing activities // The Canadian Journal for the Scholarship of Teaching and Learning. – 2014. – Vol. 5, No. 1. – Article 6. https://doi.org/10.5206/cjsotl-rcacea.2014.1.6

20 Chen C.-M., Li Y.-L. Using AI-assisted tools to support digital learning and design skills in STEM education // Comput. Educ. – 2021. – Vol. 166. – P. 104141. https://doi.org/10.1016/j.compedu.2021.104141

REFERENCES:

1 Aitbaev A.Zh., Tulegenova M.K. (2020). Razvitie vizual'noi gramotnosti u studentov biologii: sovremennye podkhody [Development of Visual Literacy in Biology Students: Modern Approaches]. Vestnik KazNPU, no. 2, pp. 45–53. (in Russian).

2 Schönborn K.J., Anderson T.R. (2009). The importance of visual literacy in molecular and cellular biosciences. Int. J. Sci. Educ., vol. 31, no. 15, pp. 2043–2067. (in English). https://doi.org/10.1080/09500690802321017

3 Wiles, A.M. (2016). Figure analysis: A teaching technique to promote visual literacy and active learning. Biochemistry & Molecular Biology Education, vol. 44, no. 4, pp. 336–344. (in English). https://doi.org/10.1002/bmb.20953

4 Mayer R.E. (2021). Multimedia Learning. 3rd ed. Cambridge: Cambridge University Press, 522 p. (in English).

5 Wu C., Sharda R., Urbaczewski A. (2021). AI-assisted creativity tools in education: Pedagogical opportunities and challenges. Educ. Tech. Soc., vol. 24, no. 1, pp. 85–97. (in English).

6 Quillin K., Thomas S. (2015). Drawing-to-learn: A framework for using drawings to promote model-based reasoning in biology. CBE—Life Sci. Educ., vol. 14, no. 1, pp. 1–16. (in English). https://doi.org/10.1187/cbe.14-08-0128

7 Kohnke L., Jarvis C. (2022). Teachers' perspectives on AI-supported educational tools: Benefits and challenges. Comput. Educ., vol. 180, p. 104422. (in English). https://doi.org/10.1016/j.compedu.2021.104422

8 Clark R.C., Lyons C. (2011). Graphics for Learning: Proven Guidelines for Planning, Designing, and Evaluating Visuals in Training Materials. 2nd ed. San Francisco: Pfeiffer, 392 p. (in English).

9 Schönborn K.J., Bils C., Cooper M.M. (2014). Representational competence in science education: The case of molecular diagrams. Int. J. Sci. Educ., vol. 36, no. 5, pp. 819–842. (in English). https://doi.org/10.1080/09500693.2013.866653

10 Kohnke L., Jarvis C. (2014). Visual literacy skills of students in college-level biology: The case of molecular diagrams. Int. J. Sci. Educ., vol. 36, no. 5, pp. 719–736. (in English). https://doi.org/10.1016/j.compedu.2021.104422

11 Schönborn K.J., Anderson T.R. (2010). Developing Visual Literacy in Biology Education: Challenges and Opportunities. J. Biol. Educ., vol. 44, no. 2, pp. 51–58. (in English). https://doi.org/10.1080/00219266.2010.9656194

12 Arneson J.B., Offerdahl E.G. (2018). The Visualization Blooming Tool: A Framework for Assessing Biology Students' Visual Literacy Skills. CBE–Life Sci. Educ., vol. 17, no. 1, pp. 1–13. (in English). https://doi.org/10.1187/cbe.17-05-0085

13 Cohen J. (1988). Statistical Power Analysis for the Behavioral Sciences. 2nd ed. New York: Routledge, 567 p. (in English).

14 Schönborn K.J., Anderson T.R. (2010). A model for visual literacy in biology education. Int. J. Sci. Educ., vol. 32, no. 12, pp. 1663–1686. (in English). https://doi.org/10.1080/09500690903269895

15 Plass, J.L., Heidig, S., Hayward, E.O., Homer, B.D. (2013). Um, E. Incorporating Motivation into Multimedia Learning // Learning and Instruction, vol. 29, pp. 171–173. (in English). https://doi.org/10.1016/j.learninstruc.2013.04.003

16 Mayer R.E., Fiorella L. (2018). Ethical Guidelines for Educational Research. British Educational Research Association (BERA), London, UK, pp. 334–343 (in English).

17 Tversky B., Morrison J.B., Betrancourt M. (2002). Animation: Can it facilitate? Int. J. Hum.-Comput. Stud., vol. 57, no. 4, pp. 247–262. (in English). https://doi.org/10.1006/ijhc.2002.1017

18 Moreno R., Mayer R.E. (2007). Cognitive principles of multimedia learning: The role of modality and contiguity. J. Educ. Psychol., vol. 99, no. 2, pp. 382–389. (in English). https://doi.org/10.1037/0022-0663.99.2.382

19 Bell, J. C. (2014). Visual Literacy Skills of Students in College-Level Biology: Learning Outcomes following Digital or Hand-Drawing Activities. The Canadian Journal for the Scholarship of Teaching and Learning, 5(1), Article 6. (in English). https://doi.org/10.5206/cjsotl-rcacea.2014.1.6

20 Chen C.-M., Li Y.-L. (2021). Using AI-assisted tools to support digital learning and design skills in STEM education. Comput. Educ., vol. 166, p. 104141. (in English). https://doi.org/10.1016/j.compedu.2021.104141

БОЛАШАҚ БИОЛОГ МҰҒАЛІМДЕРГЕ ЖАСАНДЫ ИНТЕЛЛЕКТ КӨМЕГІМЕН ДЕРЕКТЕРДІ ВИЗУАЛИЗАЦИЯЛАУ ДАҒДЫЛАРЫН ДАМЫТУ

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Аңдатпа. Бұл зерттеуде болашақ биология мұғалімдерінің визуалды сауаттылығын арттыру мақсатында жасанды интеллект (ЖИ) құралдарымен ұштастыра қолдану мүмкіндігі қарастырылады. Визуалды сауаттылық – ғылыми визуализацияларды тиімді түсіндіру және жасау қабілеті – қазіргі биологиялық білім беруде шешуші рөл атқарады, алайда педагогтарды даярлау бағдарламаларында әлі де жеткілікті деңгейде дамымаған.

Жұмыстың теориялық та, практикалық та маңызы бар. Теориялық тұрғыда ол мультимедиялық оқыту және когнитивтік жүктеме теориясына сүйеніп, ЖИ студенттерге анық әрі ғылыми тұрғыда дәл визуализация жасауға қалай көмектесе алатынын көрсетеді. Практикалық тұрғыда зерттеу ЖИ қолданудың техникалық кедергілерді азайтып, студенттердің көрнекі әрі педагогикалық тұрғыдан мәнді инфографика жасауына ықпал ететінін дәлелдейді.

Эксперимент Абай атындағы Қазақ ұлттық педагогикалық университетінің биология бағытындағы екінші курсында оқитын 48 студент арасында жүргізілді. Зерттеу дизайны үш кезеңнен тұрды: бастапқы тестілеу, ЖИ қолдана отырып оқыту және қорытынды бағалау. Визуалды сауаттылық ғылыми дәлдік, анықтығы, креативтілігі және интерпретациясы бойынша бағаланды. Статистикалық талдау (жұпталған t-тест, Коэннің d көрсеткіші) барлық критерий бойынша орташа, бірақ мәнді жақсару бар екенін көрсетті.

Нәтижелер ЖИ қолдану арқылы оқыту визуалды сауаттылықты дамытуға ықпал ететінін растады, алайда ұзақ мерзімді әсерге жету үшін тұрақты педагогикалық қолдау қажет. Зерттеудің практикалық құндылығы – болашақ биология мұғалімдерін сыныпта тиімді коммуникацияға мүмкіндік беретін цифрлық және дизайндық дағдылармен қамтамасыз етуінде.

Кілт сөздер: *визуалды сауаттылық, биологиялық білім беру, жасанды интеллект, визуализация, болашақ мұғалімдер, инфографика дизайны.*

РАЗВИТИЕ НАВЫКОВ ВИЗУАЛИЗАЦИИ ДАННЫХ У БУДУЩИХ УЧИТЕЛЕЙ БИОЛОГИИ С ПОМОЩЬЮ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА

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Аннотация. В исследовании рассматривается возможность использования инструментов искусственного интеллекта (ИИ) для повышения визуальной грамотности будущих учителей биологии. Визуальная грамотность – умение интерпретировать и создавать эффективные научные визуализации – имеет решающее значение для современного биологического образования, однако в программах подготовки педагогов она по-прежнему недостаточно развита.

Работа имеет как теоретическую, так и практическую значимость. Теоретически она опирается на теорию мультимедийного обучения и когнитивной нагрузки, показывая, как ИИ может поддерживать студентов в создании ясных и научно корректных визуализаций. Практически исследование демонстрирует, что использование ИИ снижает технические барьеры и способствует созданию студентами наглядных и педагогически значимых инфографик.

Эксперимент был проведён среди 48 студентов второго курса биологического направления подготовки в Казахском национальном педагогическом университете имени Абая. Дизайн включал три этапа: исходное тестирование, обучение с применением ИИ, а также итоговую оценку. Визуальная грамотность оценивалась по критериям научной точности, ясности, креативности и интерпретации. Статистический анализ (t-тест для связанных выборок, d Коэна) показал умеренное, но значимое улучшение по всем критериям.

Результаты подтверждают гипотезу о том, что обучение с применением ИИ способствует развитию визуальной грамотности, хотя для долгосрочного эффекта требуется постоянное педагогическое сопровождение. Практическая ценность исследования заключается в оснащении будущих учителей биологии цифровыми и дизайнерскими навыками для эффективной коммуникации в классе.

Ключевые слова: *визуальная грамотность, биологическое образование, искусственный интеллект, визуализация, будущие учителя, дизайн инфографики.*