

**EFFECTS OF DIGITAL PROGRAMS ON THE LEVEL OF FORMATION OF  
DIGITAL SKILLS OF THE STUDENTS**

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**Article Info**

Received: Oct 13, 2024

Revised: Dec 24, 2025

Accepted: Sep 26, 2025

OnlineVersion: Oct 12, 2025

**Abstract**

Global changes in information, communication, professional, and other spheres of modern society necessitate several adjustments in educational practices. In preparing integrated tasks, students are taught to apply knowledge from various subjects to solve specific problems. One of the most important conditions for enhancing the effectiveness of the educational process is the development of students' research and digital skills, which in turn fosters their creative and logical thinking abilities. This study employed a quasi-experimental research design. The sample consisted of 46 second-year chemistry-biology students (23 in each group) from the Kazakh National Women's Teacher Training University during the second semester of the 2022-2023 academic year. The experimental and control groups were randomly selected. Key findings include a 7.7% improvement in digital skills among the experimental group compared to the control group (a high level of 48.3% in the experimental group, compared to 40.6% in the control group). The verification of integrated tasks indicates that digital skills involve understanding the purpose, conditions, and means of action. These skills are aimed at researching and clarifying specific processes, facts, and phenomena, while effectively utilizing knowledge and life experience. This research contributes novel insights by demonstrating how integrated tasks enhance digital competency within a chemistry-biology curriculum. The findings suggest that incorporating such methodologies into educational frameworks can bridge the gap between theoretical knowledge and practical application, ultimately improving students' readiness for the digital economy and research-oriented careers.

**Keywords:** Digital Programs, Ecophysiology Course, Jamboard, Miro, Quasi-Experimental Study



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## INTRODUCTION

The main components of enhancing the efficiency of the educational process lie in developing students' research and digital skills, as these not only help learners master subject-specific content but also cultivate creativity, logical reasoning, and intrinsic motivation for lifelong learning (Weller, 2003; Černochová et al., 2018; Al-Momani et al., 2024; Asmaningrum et al., 2025). In higher education, particularly in science-related courses such as ecophysiology, the integration of digital tools can create innovative and interactive learning environments. This study, conducted as part of the project "IP202407 – Studying the Direction of Solving World Problems by Integrating the SDGs into the Educational Process," aims to determine the effectiveness of digital programs such as Jamboard and Miro in developing students' digital competencies within the context of ecophysiology learning.

The practical relevance of integrating these digital platforms lies in their ability to promote algorithmic thinking and adaptive learning through collaborative and visual activities. Prior research has demonstrated that digital learning environments improve time efficiency, flexibility, and the quality of students' cognitive engagement (Bilyakovska et al., 2023; Ajadi & Ayanlowo, 2025; Demon & Santos, 2025). Moreover, complex thinking—recognized as a crucial 21st-century competency—requires the application of technology-based strategies that enhance analytical and reflective skills (Patiño, 2023; Cadiz et al., 2024; Suryani et al., 2024; Charlize et al., 2025). In this regard, designing integrated tasks that connect theoretical knowledge with practical applications provides favorable conditions for improving students' mastery of learning materials (Baitasheva & Zhamanbayeva, 2023a).

Developing students' professional and digital competencies also demands that educators strengthen interdisciplinary connections through well-structured digital resources that foster quality self-study and autonomy (Songolova et al., 2020; Zhao et al., 2021; Diaz et al., 2025; Fetmirwati et al., 2025). The application of Braun and Clarke's (2006) thematic analysis further supports the systematic exploration of qualitative data, ensuring that interpretations reflect meaningful patterns and insights. This methodological foundation provides the analytical rigor needed to assess learning processes and outcomes (Battro et al., 2005; Hafiz et al., 2025).

Furthermore, analyzing non-ideal learning scenarios helps reveal challenges and opportunities in motivating students to make informed, reflective decisions (Tierney et al., 2024; Hagad & Riah, 2025; Jackson & Alfaki, 2025). As educational practices evolve, the spaces in which teaching and learning occur are also transforming. Technology now permeates physical learning environments, creating hybrid interfaces that connect mobile, virtual, and real-world contexts (Ellis & Goodyear, 2016; Cohen & Ezra, 2018; Islami et al., 2025). This transformation supports the emergence of hybrid pedagogical models, which are increasingly recognized for their potential to facilitate meaningful, flexible, and personalized learning experiences (Goodyear, 2020; Klinaku et al., 2025; Le & Aye, 2025).

Multi-platform learning approaches (Cook et al., 2020) bridge the gap between abstract scientific concepts and practical application, thereby enriching students' engagement and understanding (Yuldasheva et al., 2021; Linh et al., 2025; Mor, 2025; Nisa et al., 2025). Despite these advancements, however, research gaps remain in exploring how digital platforms like Jamboard and Miro specifically influence students' development of digital and complex thinking skills in scientific and sustainability-oriented contexts. Previous studies have mostly examined these tools from a technological or usability perspective rather than from a pedagogical and cognitive development lens. There is still limited empirical evidence addressing how such digital tools, when integrated with sustainability-focused content like the Sustainable Development Goals (SDGs), contribute to holistic skill formation, motivation, and critical decision-making among university students.

Therefore, this study seeks to address these gaps by examining the effectiveness and pedagogical impact of Jamboard and Miro in fostering digital literacy, critical thinking, and engagement in ecophysiology learning. The findings are expected to contribute to the design of hybrid, technology-enhanced learning models that align with the principles of sustainability and interdisciplinary competence in higher education.

## RESEARCH METHOD

This study used a quasi-experimental survey design (Büyüköztürk et al., 2019). The study sample consisted of 46 second-year students (23 in each group) specializing in chemistry and biology at the Kazakh National Women's Pedagogical University during the second semester of the 2022-2023 academic year. The participants were selected using a convenient sampling method (Büyüköztürk et al.,

2019). The study lasted for 9 weeks, with the experimental and control groups randomly assigned. Both groups completed a pretest and a posttest. During the 7-week intervention period, both groups performed the same tasks. The study sample consisted of 46 second-year students (23 in each group) specializing in chemistry and biology at the Kazakh National Women's Pedagogical University. The participants were selected using a convenient sampling method (Büyüköztürk et al., 2019; Rahajo & Kumyat, 2025).

Additionally, the authors prepared integrated task verifications for the experimental group. These tasks involved digital programs, utilizing different methodological approaches, and were conducted through group work discussions. The discussions involved direct interaction between the teacher and students and were one of the most commonly used tools for planning, monitoring, and evaluation. They were held either face-to-face or via telephone or computer media. In this study, discussions were conducted on the Zoom platform. Focus groups were formed, consisting of two smaller groups that discussed specific topics using pre-prepared tasks in a moderated setting. This helped to determine the opinions and perceptions of the experimental group regarding their mastery of the methods used and the learning of work practices.

Data were collected through pre-test and post-test assessments in both the control and experimental groups using Google Forms. The results of the Google Form tests provided empirical evidence of the formation of digital skills in both groups. The quantitative and qualitative analysis of the test responses from both groups helped verify the effectiveness of the integrated tasks. The study was conducted as part of an ecophysiology course, an elective for second-year biology-chemistry students. Tasks in the ecophysiology course were completed online using the Zoom platform for 7 weeks, with both groups performing the same tasks. The verification of integrated tasks for the experimental group was prepared by the authors of the study.

Each course in the experimental and control groups included the use of textbooks, PowerPoint presentations, videos, and question-and-answer sessions, as well as responses to questions from the textbook. Students actively participated in learning activities organized by the teacher, using digital tools such as Jamboard and Miro to help master the topics. Thematic task analysis was conducted using qualitative data, following methods adapted from Braun and Clarke (2006). Students in the control group performed tasks using their own creativity, which included narration, question and answer, slides, tables, and essays (Syahrial et al., 2024). The tasks involved data analysis on digital platforms, employing various methodological approaches, and discussions were facilitated through both individual and group work. Students engaged with digital assignments specifically designed for the ecophysiology course. The incorporation of these methodological materials into the learning process helped establish a foundation for the students' information competence. Additionally, supplementary classes were organized to support the students' independent work on creative projects.

These projects aimed to develop skills in reading educational material on the computer and applying it practically. For example, in the lesson on "The Effect of Stress Factors on Plants," students discussed research on determining the functional state of plants before and after frost. These discussions took place on Jamboard using the FILA method (Dauletova, 2019; Elfeky & Elbaly, 2023). According to this collaborative learning strategy, the students separate the types of tasks, combine their work at the end, and fill in the table. Tasks are divided into four stages: F (Fact-finding): collection of relevant data; I (Inquiry): discussing the data; L (Learning): developing guiding questions; A (Action): applying learned concepts through specific activities.

Miro is a platform that enables remote learning and collaboration. It functions as a virtual whiteboard where users can write text, draw, create graphs, and charts, among other activities. Students were divided into groups and tasked with determining the general laws governing the effects of environmental factors on plant organisms using the "FILA" method. They were instructed to fill in a table on Miro. Both the experimental and control groups were assigned the task of monitoring the effects of environmental factors, such as heat, cold, salt, and gas, on plants.

All tasks were based on references from the textbook (Baitasheva & Zhamanbayeva, 2023b). Morphological and anatomical analyses were conducted to assess the influence of these factors on plants (Mussina et al., 2018) and the ecophysiological capacity of plants was determined in relation to their habitat (Issayeva et al., 2022). The experimental group completed these tasks using the Miro board (Figure 1).



Figure 1. Example of the Miro Board used by the experimental group

The control group is an example of the performance of the mentioned tasks (Figure 2).



Figure 2. Example of tasks used by the control group

Students in the control group wrote their responses to each question and supported their conclusions with data. For example, after analyzing the results, students answered the questions and then made appropriate conclusions. It was recommended that they compare their conclusions with the materials previously prepared in the textbook. As a result, by comparing their research findings with the textbook materials, the students verified that their conclusions aligned with the content of the textbook. The final stage of the study was aimed at evaluating the effectiveness of the developed methodology for the formation of digital research skills in ecophysiology classes and explaining the results of the formative experiment.

This article presents one of the possible approaches to integrating teaching methods into classroom tasks. The tasks were developed by the authors. The increasing need for participation in global processes and integration into the world educational space has led to the urgent modernization of the national education system. The study aimed to map research on the use of learning methods within the ecophysiology course (Coşkunserçe et al., 2022).

The university employed technology-supported learning strategies to enhance students' critical thinking skills. This study used motivational, substantive, and support methods, as well as an experiment to determine the effectiveness of the tasks (Trentin & Bocconi, 2014). The integration algorithm is recommended as the preferred learning method. The project included several pre-prepared tasks. In the

first method, students worked using digital platforms, while in the second, traditional methods such as tests prevailed.

In this study, a test was used as both a pretest and posttest, administered via Google Forms. The test was developed by the authors and consisted of seven questions aligned with the objectives of the ecophysiology course. After being sent to two experts, the test was validated based on feedback from academic members in the field, focusing on its content, language, duration, and scope. Their suggestions and technical requirements were taken into account in finalizing the test questions. The test included the following seven questions: 1) How do you understand the concept of integration?; 2) What digital resources do you use in class, and how effectively?; 3) Do you know how to use platforms like Jamboard, Miro, Wordwall, and Padlet?; 4) Do you know how to use a virtual laboratory?; 5) What is your understanding of digital and research competence?; 6) Explain the essence of the subject of ecophysiology; 7) How would you rate your level of proficiency in information and communication technologies?.

The test was administered as both a pre-test and post-test to the control and experimental groups. A total of 46 students voluntarily participated in the test, which had a duration of 35 minutes. The pretest was conducted three days prior to the lesson, and the test consisted of five open-ended questions and two Yes/No questions. The posttest was administered after a 7-week intervention. The development of digital skills was assessed based on the results of Google Form tests administered to the experimental and control groups. Empirical data was collected through quantitative and qualitative analysis of responses from both groups. There were two types of analysis in this study. The first type consisted of seven questions that were scored 1 or 0, and the test was conducted with the help of an educational program. The second thematic analysis of the items was conducted using qualitative data using methods adapted from Braun and Clarke (2006). This analysis focused on evaluating students' motivational, content, and operational development.

Three levels of proficiency were distinguished. Level III is the high level, indicating correct answers to the questions. Level II is the medium level, indicating partial or acceptable answers. Level I is the low level, indicating incorrect answers. Motivational, meaningful, and operational criteria were defined based on these components as benchmarks for developing digital research skills. This study anticipates several limitations that could influence the outcomes. One significant limitation is the potential technological barriers participants may face. Limited access to reliable internet could pose challenges, particularly during synchronous online sessions and while using digital platforms like Jamboard and Miro (Alavi et al., 1997; Vogel & Klassen, 2001; Saindah, 2025). Additionally, differences in participants' familiarity with these platforms may affect the pace at which tasks are completed, as some students might require additional guidance and practice to effectively utilize these tools.

Differences in prior digital experience among participants may also create disparities in the ease with which they adapt to the experimental tasks. While some students are likely to demonstrate proficiency with digital tools, others may struggle, potentially impacting the uniformity of skill development across the group (Pagani et al., 2016). These factors highlight the importance of ensuring equitable access to technology and incorporating preparatory training sessions to address these challenges in future studies.

## RESULTS AND DISCUSSION

The pre-test results of the experimental and control groups are presented in Table 1.

Table 1. Pre-test results of the experimental and the control groups

Groups	Questions													
	1		2		3		4		5		6		7	
Score	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Experimental Group	6	17	4	19	1	22	0	23	2	21	6	17	10	13
Control Group	5	18	3	20	0	23	2	21	5	18	4	19	12	11

In Table 1, no significant differences were observed between the pre-test results of the experimental and control groups, as both groups exhibited low levels of digital skills. This finding underscores the necessity of motivation in conducting the ecophysiology course.

A high level of digital skills can be defined as follows: an interest in conducting various types of research, the ability to approach problem-solving independently and creatively, the acquisition of essential research skills and knowledge, a high level of analysis using digital resources, and a significant degree of independence. The average level is characterized by emerging external motivations for conducting research, the ability to identify problems with the assistance of a teacher, and the ability to propose various solutions.

Students at this level can utilize digital resources with teacher support and demonstrate some basic skills in performing tasks using these tools. The low level is formed from skills acquired spontaneously, which may be described as follows: a low level of interest, a lack of knowledge and skills necessary to work with digital resources on assigned tasks, and an absence of leadership or personal perspectives. Significant efforts were made to motivate students over the 7-week period. The experimental group engaged in discussions on course topics using digital resources, while the control group expressed their creativity in completing tasks. According to the results of the post-test administered after 7 weeks, there was a noticeable increase in the students' skill levels. The results of the post-test can be seen in Table 2.

Table 2. The post-test results of the experimental and the control groups

Groups	Questions													
	1		2		3		4		5		6		7	
Score	1	0	1	0	1	0	1	0	1	0	1	0	1	0
Experimental Group	20	3	23	0	23	0	21	2	22	1	18	5	20	3
Control Group	15	8	13	10	12	11	14	19	20	3	13	10	13	10

According to Table 2, the post-test results for the experimental group indicated an increase in the number of students who mastered the concepts of integration and ecophysiology. Specifically, 23 students demonstrated full mastery of digital competence, successfully completing ecophysiology tasks on Jamboard and Miro.

Similarly, the post-test results for the control group showed an increase in the number of students who understood the concepts of integration and ecophysiology. Among them, 13 students achieved full mastery of digital competence. However, only 11 students were able to perform ecophysiology tasks effectively on Jamboard and Miro. The number of students who could utilize virtual laboratories reached 19, reflecting high levels of ICT proficiency. Notably, 13 students were unable to fully complete the pre-prepared tasks. The results of the pedagogical experiment demonstrated the sufficient effectiveness of the developed methodology for enhancing analytical skills on digital platforms in ecophysiology classes (Table 3).

Table 3. Analysis on digital platforms monitoring of the development of skills

Criteria	Groups	Levels		
		III %	II %	I %
Motivational	EG	68.4	20.6	11
	CG	60.4	26.5	13.1
Content	EG	15.8	55.2	29
	CG	12.9	57.4	29.7
Operational	EG	60.6	21.2	18.2
	CG	48.4	28.3	23.3
Total	EG	48.3	32.3	19.4
	CG	40.6	37.4	22

EG: Experimental Group; CG: Control Group

Table 3 presents an analysis of the development of skills on digital platforms. The total result for the experimental group, at 48.3%, was higher than that of the control group. The analysis focused on skills related to digital platforms. Figure 3 illustrates the dynamics of analytical skill development on these platforms in a histogram.

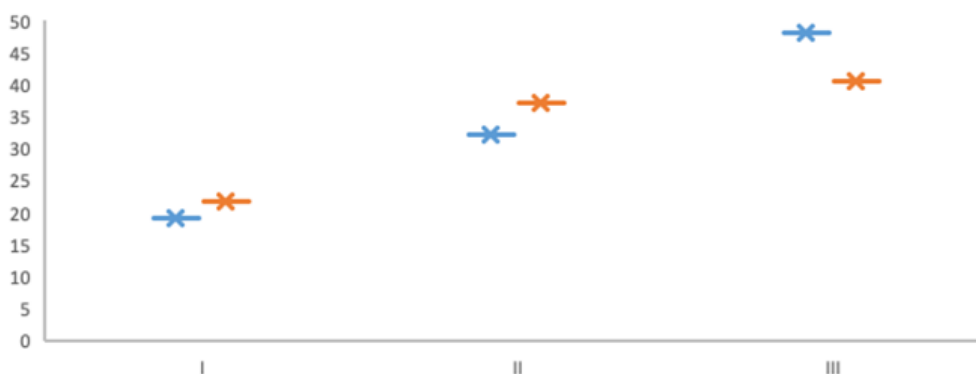


Figure 3. Dynamics of development of analytical skills on digital platforms

EG: Blue colour and CG: Red colour

As shown in Figure 3, the pedagogical experiment demonstrated that the development of digital skills among the experimental group of students was significantly enhanced through the use of digital platforms. The data indicate that the methodology employed in the ecophysiology course effectively facilitated the development of digital skills based on the verification of integrated tasks. This study demonstrated the effectiveness of using prepared resources in the ecophysiology course. A notable aspect of the course was the inclusion of both control and experimental groups. The findings indicated that employing various digital methods for training processes yielded high effectiveness (Aubakir et al., 2023). There was no significant difference between the mean preliminary testing results of the experimental and control groups, suggesting low digital skills overall. This highlights the necessity of motivation for conducting the ecophysiology course effectively.

In the context of motivation, four factors are crucial for fostering interest in tasks. These include enhancing the quality of outcomes by providing students with engaging and satisfying work, promoting self-organization and self-management, increasing feedback through collaborative goal-setting, and improving performance quality via incentives and consequences. Three factors influence the content or meaning of information in tasks. These are the determination of the message by the amount of knowledge it conveys to the recipient, the distinction between content and form, emphasizing a personal approach that transcends mere facts to achieve deeper understanding, and the identification of self-improvement opportunities alongside the expansion of knowledge with each educational experience. Reducing uncertainty in knowledge allows for the quantitative measurement of information (Shchedrovitskiy, 2015).

Post-treatment results from the study demonstrated a positive effect, confirming that task completion on the digital platform was time-efficient and facilitated understanding of the material (Anderson, 2008). The study significantly enhanced motivation through online assignments delivered via the Zoom platform, making lessons more engaging (Hidayat et al., 2024). This is evidenced by the differences in test results between the groups after the intervention. Based on these findings, it can be concluded that students had access to open resources online (Sun & Chen, 2016). Krumsvik (2011) further emphasized the importance of developing digital competence as a crucial element of the education system, highlighting the relevance of this in the modern educational system (Kim & Bonk, 2006).

It is important to organize certain stages of mastering these skills to increase the effectiveness of digital skills development through the testing of integrated tasks. The first stage is goal setting (motivational), where clear objectives are established. The next stage is familiarization, which involves understanding the actions to be mastered. Following that is knowledge acquisition, where individuals master or restore the knowledge that fosters these skills, while also formulating the rules for implementing actions (meaning). The fourth stage is modeling, where examples of the desired activity are provided. This is followed by practical development, which involves engaging in activities to cultivate the appropriate skills. The last stage is independent practice, consisting of regular exercises to reinforce learning (operational).

An analysis utilizing an operational approach identified six internal factors essential for quality assurance in education. These include process planning, development of a quality assurance system, research based on real-world operations, the capability to monitor the process and provide verification indicators, effective management of digital platforms, and the formation of functional literacy along with

the development of critical thinking. Additionally, conducting control and monitoring evaluations is also a crucial factor (Chianchana & Wichian, 2020).

Future studies could benefit from a larger sample size. Additionally, employing a variety of data collection methods – including observations, textual or visual analysis (from books or videos), and interviews (individual or group) – would enrich the research. In qualitative research, when utilizing a qualitative content analysis methodology, the research process should be described from planning to presentation, with a strong emphasis on reliability throughout (Mariette, 2016). Considering the educational resources and organizational-pedagogical features of massive open online courses, the advantages of this approach have proven effective in mastering the subject matter (Bennett et al., 2020). Ross et al. (2014) suggest that the development of education and the widespread introduction of open online courses with large collections of learning materials, lectures, and assignments will contribute to the creation of technologies and a unified information and educational environment as part of a new educational model, which will ultimately lead to the formation of students' digital competence.

## CONCLUSION

Digital learning increases students' independence and motivation, which are important for professional activities in the global digital environment. The use of digital resources had a positive impact on learning outcomes over 7 weeks. The increase in the number of digital tasks had a positive impact on the learning process, as the tasks created within this model promoted the use of interactive methods. The developed assignments improved accessibility and promoted wider use during training due to the possibility of adjusting the parameters. The verification of integrated tasks underscores the importance of digital skills, which involve understanding the purpose, conditions, and means of action aimed at researching and clarifying specific processes, facts, and phenomena. This approach emphasizes the effective use of knowledge and life experience. Grounded in the personality-activity framework, we found that research skills are complex and consist of three components: motivation, which manifests as cognitive interest; semantic knowledge (the knowledge system); and operational skills (the skill system). In an experiment involving 46 respondents, it was demonstrated that students who participated in the ecophysiology course significantly improved their digital skills. By completing prepared tasks in advance, they enhanced the quality of their integrative thinking. Over the course of 9 weeks, the experimental group performed better on the Jamboard and Miro platforms compared to the control group. The increase in the experimental group's proficiency in verifying tasks related to the ecophysiology course serves as evidence of the effectiveness of digital assignments.

## ACKNOWLEDGMENTS

Thank you to all colleagues who have helped, so that this research can be carried out and completed.

## AUTHOR CONTRIBUTIONS

Author 1-2 creates articles and creates instruments and is responsible for research, author 3-4 analyzes research data that has been collected, author 5 assist in research data analysis, instrument validation, and input research data.

## CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

## USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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