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Pedagogical methods of formation of ecological and critical skills of future teachers of natural sciences using digital technologies

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Abstract

The article discusses pedagogical methods for developing ecological and critical skills in future teachers of natural science disciplines, exploring ways to foster the development of these skills in future educators. Particular attention is given to approaches that promote the integration of ecological knowledge and critical thinking in the educational process using digital technologies and GIS. The study involved 76 studensts from two universities and 155 secondary school students. The pedagogical experiment was conducted in four stages: theoretical, practical, analytical, and final. Particular focus was given to using GIS technologies to develop students' spatial analysis skills and encourage research activity. The results showed that 85% of biology students and 79% of geography students achieved the learning objectives at the levels “excellent” and “good,” respectively. The effectiveness of the proposed methodology is confirmed by these results, and it can be recommended for use in training future teachers.

Keywords: Critical thinking, Digital technologies, Environmental skills, Future teachers, GIS, Kazakhstan, Natural sciences, Pedagogical methods.

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1. Introduction

In the context of global environmental change and deteriorating relations between humans and the natural environment, it is increasingly important to develop the geographical awareness of the younger generation. Geographical culture,

comprising knowledge, skills, and value orientations, shapes students' understanding of the interplay between natural and social processes, fostering an environmentally conscious mindset and a sense of responsibility.

At the same time, training future science teachers requires new approaches that introduce environmental literacy into the educational process. Future teachers play a crucial role in developing systems thinking in students, equipping them to solve complex sustainable development challenges.

When preparing future biology teachers in environmental skills, the following basic elements must be considered:

Environmental literacy: it is crucial for future biology teachers to develop environmental competence, which has three levels: low (unconscious incompetence), medium (conscious incompetence), and high (conscious competence) [1].

Methodological approaches: Training should include a competence-based approach, innovative technologies, interactive teaching methods, and tools that solve problems effectively and develop environmental literacy [2].

Thinking about the future and sustainability: education should focus on developing future-oriented thinking skills, such as future planning, positive future thinking, forecasting, imagining future scenarios, assessing future prospects, and preparing future biology teachers to address sustainability issues [3].

Training future geography teachers based on environmental literacy requires a focus on developing their methodological competence to meet modern training requirements for university specialists.

This involves studying the methods of teaching geography and mastering methodological knowledge, skills, and pedagogical reflection through the study of pedagogical experience [4].

Developing research skills and geographical thinking is achieved through courses such as 'Fundamentals of Geoecology' which equip geography teachers with the knowledge and skills needed to conduct research and teach the theoretical foundations of landscapes.

Educate future geography teachers in ecological culture that encompasses environmental knowledge, skills, awareness, thought processes, and behaviors that can be applied to their professional activities.

Include the context of sustainability (environmental, economic, and socio-cultural aspects) in teacher training for environmental education, focusing not only on education but also on raising awareness and taking action to achieve sustainability [5].

This study aims to develop and substantiate pedagogical methods for forming geographical culture in students based on environmental skills in future natural science teachers. The following tasks were completed within the framework of the study:

- To study the theoretical foundations of geographical culture and environmental education, and their interrelation and influence on the educational process.
- To study pedagogical methods and approaches aimed at integrating environmental knowledge into biology and geography teaching, and to test the methods proposed by the authors.
- To analyze the results of the pedagogical experiment and determine the effectiveness of the proposed methods.

The research was based on the following methods: theoretical analysis of scientific literature, pedagogical experimentation, questionnaires, testing, and control.

This work contributes to the development of pedagogical science by offering new approaches to forming geographical culture and environmental skills, which can be implemented in schools and teacher training colleges.

2. Literature Review

Geographical culture is reflected in cultural heritage and the landscape. It can be studied through cultural geography, in conjunction with related disciplines such as history, architecture, and anthropology. Geographical barriers, such as natural features with different characteristics, can contribute to the formation of regional cultures by limiting the exchange of material and informational resources. Forming students' geographical culture requires a multifaceted approach combining various academic subjects, such as history, social studies, and geography.

In grades 5–6, students learn the basics of map reading and develop a foundation in cartography, which they then apply to each subject, as well as acquiring basic knowledge of biology, geography, chemistry, and physics [6].

In Year 7, students consolidate and develop their map-reading and working skills, as well as their ability to analyze and compare thematic maps to obtain new information and establish connections between natural and social phenomena.

In Year 8, students develop new skills in working with topographic maps. They learn to use maps to solve problems related to local and time zones and continue to develop their ability to analyze and compare thematic maps to identify causal relationships between natural and social phenomena [4].

Forming a cultural and geographical image of a country is an important aspect of geographical and cultural development that can be incorporated into humanities teaching [7].

Another way to develop the ecological culture of students is through the development of noosphere thinking through research and project activities [8].

These approaches aim to provide students with the knowledge and critical thinking skills necessary to understand the complex relationships between geographical, historical, and social factors that shape a region's or country's cultural identity.

Geographical thinking and environmental education are closely related. Geography plays an important role in developing a systematic and comprehensive understanding of the environment. Geography courses should cover the historical development of natural and social elements, as well as future prospects, since a deep knowledge of one's region contributes to a broader understanding of the environment. The eco-museum concept has the ability to influence ecological thinking, so it can contribute to the development of ecological thinking in environmental education [9]. This development is crucial in creating a sustainable manifestation of ecological culture in individuals' minds [10].

The development of geographical thinking requires an update to the subject's conceptual and methodological framework, based on the study of the fundamental principles that have shaped its identity. This update is intended to address the specific spatial and everyday issues that students face [11]. Furthermore, research indicates that effective environmental education should extend beyond mere awareness-raising to actively engage students in solving genuine environmental issues [12]. It should be based on real-life experiences and aimed at developing practical environmental protection activities that take into account students' age-related characteristics [13]. Overall, integrating geographical thinking and environmental knowledge is essential for fostering a holistic understanding of the environment and encouraging active engagement in addressing environmental issues [14].

As a science that studies the patterns of development of environmental education and defines its strategic goals and leading directions, environmental pedagogy plays a leading role in general education and is a subject-oriented pedagogy that forms the intellectual basis of the environmental school [15].

Among the main general cultural tasks of environmental education that require careful didactic processing is the task of teaching students, as presented in Figure 1 [16].

The importance of developing eco-skills lies in their ability to analyze and understand the impact of climatic factors on the economy. For instance, Khrolenko [2] found that there was a negative short-term correlation between rising temperatures and GDP per capita in North Africa and the Sahel between 1965 and 2020, and a positive long-term correlation between precipitation and economic growth [17].

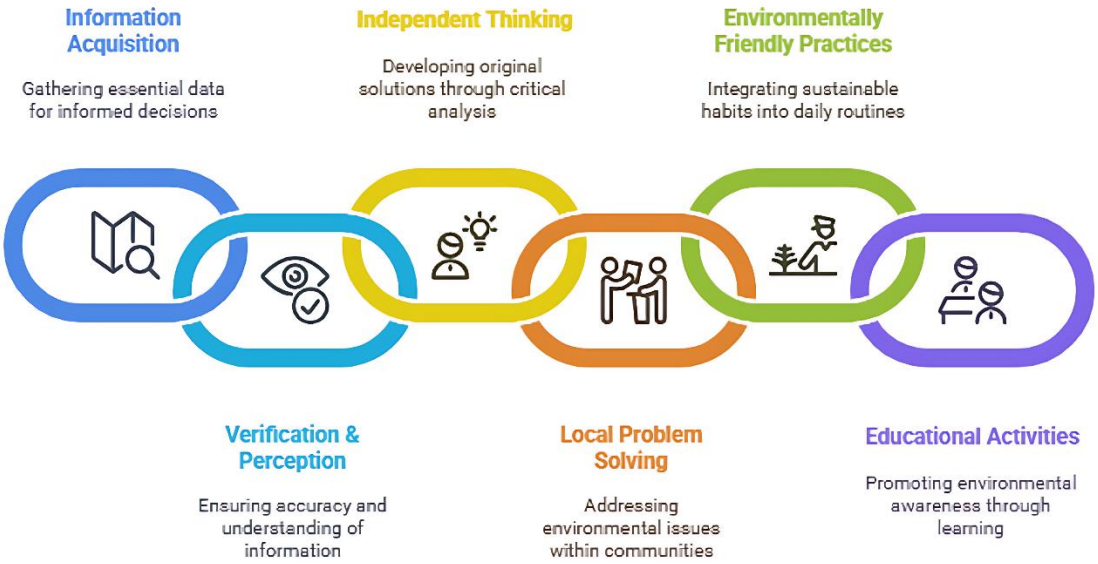

Figure 1.
The main general cultural objectives of environmental education.
Source: Zakhlebny and Dzyatkovskaya [16].

Among the theoretical research methods used in teaching environmental methods, one can distinguish the following:

System-structural analysis allows us to identify relationships between goals, content, forms, methods, and approaches to acquiring knowledge.

Mathematical and statistical methods are also used. The comparative method of processing experimental results when writing a term paper allows for a wide range of methodological approaches to solving the problems of teaching the discipline of ecology, taking into account their theoretical background and individual style of thinking.

Empirical research methods include observations, conversations, questionnaires, studying documentation, conducting research in pedagogical practice, generalizing advanced pedagogical experience conducted in laboratory and practical classes, and educational experiments [18]. An important part of the professional education of future teachers is pedagogical experience. This includes modern teaching methods and technologies such as interactive teaching methods, project-based learning, problem-based learning, and critical thinking development technologies. It serves as a tool for transforming the professional and personal experience of future teachers. During pedagogical practice, pedagogical, psychological, methodological, and managerial competencies are developed that are integral to the professional competence of a future teacher [19]. Observation is the primary method of empirical cognition and allows us to obtain primary information about objects. When conducting educational practice, observations should take the form of scientific observations, in accordance with a methodology that corresponds to the object of research [20].

One approach to preparing future geography teachers for ecology is to introduce innovative teaching technologies, such as interactive methods, case studies, and project-based learning. These help future geography teachers develop the competencies necessary for effective environmental education [21]. Working with maps and developing cartographic skills, including acquiring new geographical knowledge, are also important aspects of preparing geography teachers to deliver effective environmental education [22].

Generally speaking, training future geography teachers in ecology requires an integrated approach combining innovative teaching methods, environmental knowledge integration into the curriculum, cartographic competence development, and methodological competence formation [23].

This article, which focuses on training future biology teachers in environmental skills, takes a systematic approach to analysis. It showcases the existing literature, empirical research, and best practices related to the integration of environmental education into teacher training programs.

The research demonstrated the importance of training future biology and geography teachers to develop students' geographical awareness through environmental education. Particular focus is given to the learning process of higher education students (university level): they develop their own environmental knowledge and skills and master effective pedagogical methods.

The level of environmental knowledge among students, their understanding of pedagogical approaches, and their willingness to apply these approaches in practice have been studied. During their teaching practice, students experimented with various methods of developing geographical awareness in schoolchildren through environmental education. This enabled them to analyze the effectiveness of these methods.

Thus, this study complements existing work by examining the specific pedagogical techniques used by students during teaching practice and the outcomes of their implementation. The logical sequence of pedagogical experience is as follows: preparing students; teaching the formation of geographical culture through environmental skills; conducting the experience; and applying the methods. This helps build a logical chain from preparing students to their subsequent work with them, contributing to the formation of geographical culture through environmental education.

2.1. Research problem

In the face of global environmental challenges and the increasing need for sustainable development, improving the training of future biology and geography teachers is crucial. While the importance of environmental education and geographical thinking is widely recognized, there is still a gap in the methodological training of future teachers when it comes to effectively integrating environmental knowledge and skills into the school curriculum. Current pedagogical approaches often fail to foster a comprehensive geographical awareness among students or encourage systemic environmental thinking. Therefore, it is necessary to develop and implement pedagogical methods that will equip future science teachers with environmental and geographical competencies. This will enable them to foster environmental awareness and sustainable behavior among their students.

2.2. Hypothesis

Integrating pedagogical methods that focus on nurturing environmental skills and geographical thinking into the training of future biology and geography teachers will significantly enhance their capacity to foster geographical culture and environmental awareness among their students.

2.3. Research Questions

1. What are the most effective pedagogical methods for integrating environmental skills into the training of future biology and geography teachers?
2. How do these methods contribute to the development of students' geographical thinking and geographical culture?
3. How does implementing these methods during teaching practice influence students' environmental awareness and behavior?
4. What challenges do future teachers face when applying these methods in real educational settings, and how can these challenges be overcome?

2.4. Research Objectives

The main objective of this study is to develop and justify pedagogical methods for forming geographical culture in students by integrating environmental skills into the training of future biology and geography teachers.

To achieve this, the following *specific objectives* have been formulated:

- Explore the theoretical foundations of geographical culture and environmental education and analyze their interconnection in the context of teacher training.
- Identify and systematize effective pedagogical methods and approaches that integrate environmental knowledge and skills into the teaching of the natural sciences.
- To develop a methodological framework for training future teachers to foster environmental literacy and geographical thinking in school students.
- Organize and conduct a pedagogical experiment to test the proposed methods in real educational settings.
- Evaluate the effectiveness of the developed methods in shaping students' geographical culture and environmental awareness.
- To provide practical recommendations for improving teacher training.

3. Materials and Methods

The research section of the article presents the results and analysis of questionnaires completed by university students and teachers in Almaty. The survey was completed by future teachers studying geography and biology in the natural sciences.

The figure below illustrates the sequential steps involved in the research methodology using a flowchart, and Table 1 provides information about the participants in the experiment.

Table 1.
Information about the participants of the experiment

Name of the university	Course	Quantity	Name of the school	Class	Quantity
Almaty Humanitarian-Economic University	3	31	School-gymnasium No. 36	10-11 (10 «А», 10 «Ә», 11 «А»)	78
Kazakh National Women's Pedagogical University	4	4	School-gymnasium No. 81	9 («А», «Ә», «Б»)	77
General	2	76	2	6	155

The survey aimed to establish the current level of geographical and ecological awareness among future teachers and secondary school students. This information was used to identify existing gaps and inform the development of targeted pedagogical strategies. Figure 1 shows the methodological structure of the research in the form of a flowchart.

Figure 2 outlines the research methodology, which takes a step-by-step approach from literature review to data collection, analysis, and interpretation. The process explores how ecological skills contribute to the development of geographical culture among future teachers, employing qualitative and quantitative methods to ensure comprehensive results.

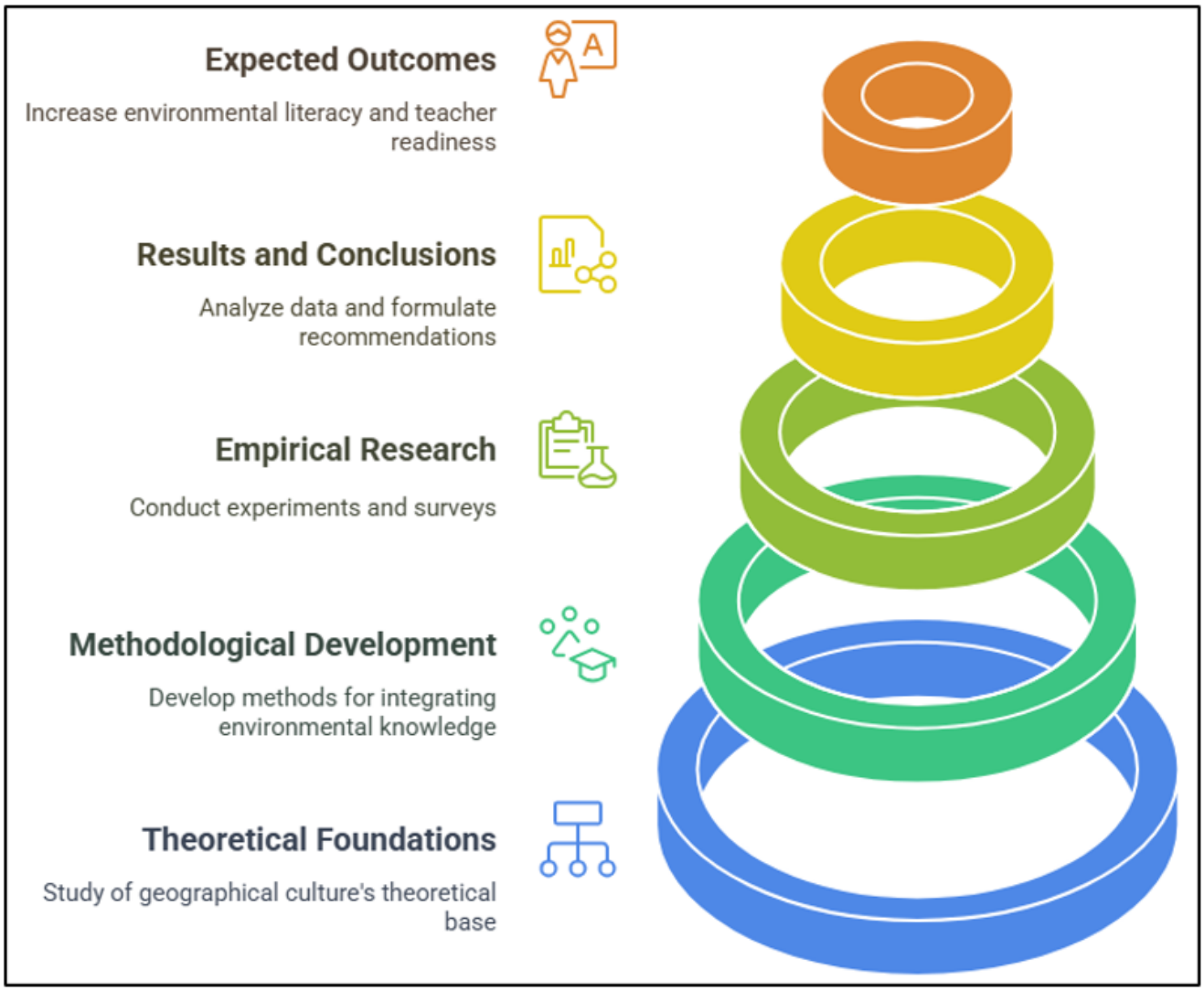

Figure 2.
Research methodology flowchart.

The materials and methods used in the research presented in this article were compiled by doctoral students and their supervisors at KazNU and KazNPU in the 2022/23 academic year. Depending on the nature and relevance of the doctoral thesis content, the experimental practice was conducted from April to September 2024 (i.e., the second half of the 2023/24 academic year and the first half of the 2024/25 academic year). The interviews were conducted directly with students and with the authors' students. The experiment consisted of four stages and was conducted in the same way as the musculoskeletal circuits shown in Figure 3.

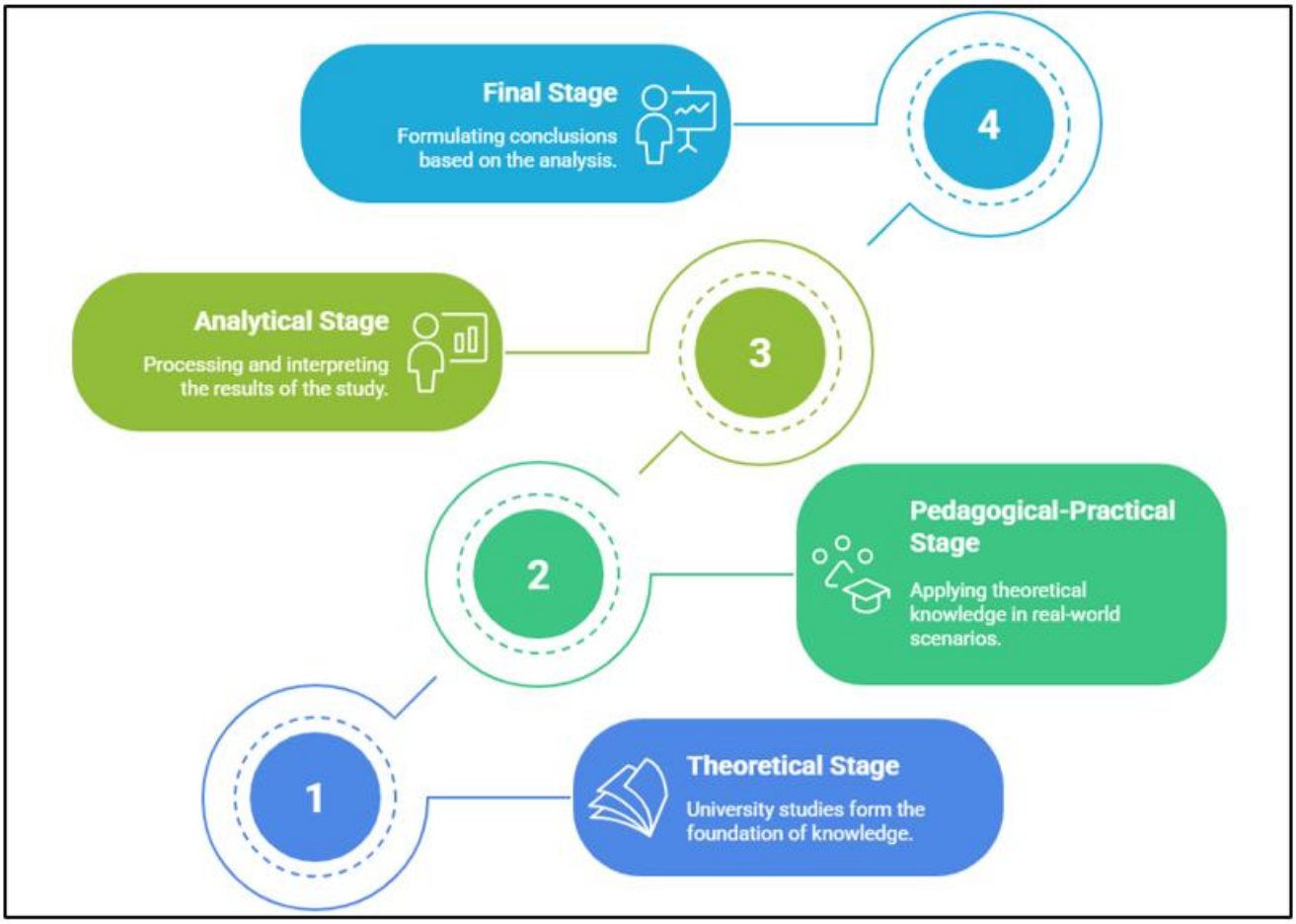

Figure 3.
Stages of pedagogical and experimental practice.

At the theoretical stage, a survey of students was conducted to assess the knowledge gained through the university program, based on environmental skills. At the practical pedagogical stage, students applied their theoretical knowledge by preparing an abbreviated periodic plan for the first lesson and implementing it in practice. The abbreviated periodic plans presented in Table 2 are an example of those drawn up by students. Students were able to draw up an abbreviated periodic plan and a calendar-thematic plan, as well as determine the lesson's learning objectives. At the analytical stage, the results were processed using modelling, quantitative, and qualitative methods. In the final stage, the concept is derived and recommendations are made to future researchers.

During the theoretical stage, students attended lectures on the subjects of “Methods of Teaching Geography” and “Methods of Teaching Biology”. In practical classes, a calendar plan and an abbreviated periodic plan were drawn up. Abbreviated periodic plans have been developed for students, and tasks to develop “Environmental skills”, “Ecological thinking”, “Geographical thinking”, “Critical thinking”, and “Geographical culture” have been integrated into the lesson content. The table below shows an example of an abbreviated periodic plan drawn up by students.

Table 2.
Lesson plan for the formation of environmental and critical skills of future natural science teachers.

Biology lesson plans for 9th grade	
Topic: "The impact of mining and pesticides on the environment and human health". Objective: To form students' ecological thinking by analyzing the negative impact of economic activity on nature and health. Introductory part (10 minutes): Greetings, setting the lesson goal. A video or presentation on mining and the use of pesticides. Main part (25 minutes): Discussion of the causes and consequences of environmental pollution. Group work: analysis of the conditions of exposure to mining and pesticides (based on pre-prepared materials). Filling in the "Problem – consequences – solutions" table. Practical work (15 minutes): Students create a poster or infographic about the harm of pesticides and pollutants to ecosystems. The final part (5 minutes): Reflection: "How can we change our behavior to reduce the harm to nature?"	Topic: "Greenhouse effect and thinning of the ozone layer". Objective: To develop ecological thinking by studying global climate change and its consequences. Introductory part (10 minutes): Brainstorming session "What is the greenhouse effect and how does it affect the planet?" Displaying tables of changes in Earth's temperature over the past decades. Main part (25 minutes): Lecture with discussion elements: Greenhouse effect: Causes and consequences. Ozone layer thinning and its impact on human health and ecosystems. Pair work: building a chain of "Cause – phenomenon – effect". Practical work (15 minutes): To conduct an experiment using glass containers to simulate the greenhouse effect. Final part (5 minutes): Final discussion: "How do our actions affect the climate?"
Geography lesson plans for grades 10-11	
Topic: "Designing environmentally friendly industries". Objective: To develop geographical thinking skills through the development of projects for environmentally sustainable enterprises. Introductory part (10 minutes): Discussion: "What is environmentally friendly production? Examples of life". The main part (25 minutes): A short lecture on the principles of environmentally sustainable production. Teamwork: Development of a model of an environmentally friendly enterprise, taking into account local conditions (for example, a processing plant). Project presentation (15 minutes): Groups defend their projects in front of the class. The final part (5 minutes): Voting for the best project. Reflection: "How can we contribute to sustainable development?"	Topic: "Studying the environmental problems of Kazakhstan through geographic information systems (GIS)" (Topic 26: Environmental quality assessment. 11th grade). Purpose: To study the environmental problems of Kazakhstan using GIS technologies and to develop the geographical thinking of students. Introductory part (10 minutes): A question for the class: "How to see environmental problems on a map? What is GIS?" A brief overview of the GIS concept and its role in the study of the environment (brief explanation, slide 2-3). Presentation of the main ecological zones of Kazakhstan (air pollution in the Aral Sea, Balkhash, and Almaty). The main part (25 minutes): Teamwork: Each group works with a map or a set of GIS-based data (for example, https://gis.kz or pre-prepared maps). Each group is given a specific environmental problem (the Aral Sea, the Semipalatinsk landfill, industrial pollution, etc.). Task:
- Find the location of the problem on the GIS map. - Consideration of additional layers (pollution level, relief, population density). - Identify the causes and consequences of the problem and suggest possible solutions. The result: Each group makes a small 3-minute presentation. Practical work (15 minutes): - Students use an interactive map (GIS platform or paper version) to identify regions of Kazakhstan with environmental problems. - Builds a map with legends, colors, and symbols. Work in pairs or small groups. Final part (5 minutes): Discussion: "How can GIS help us solve environmental problems?" Reflection: Each student tells in one sentence what he learned in the lesson.	

The lesson plans in Table 2 demonstrate how environmental and critical thinking skills can be cultivated in prospective science educators. Each lesson uses active learning methods such as discussions, group work, and project-based learning to promote analytical and reflective abilities. Particular emphasis is placed on using digital tools, especially GIS, in geography

lessons to develop pupils' spatial thinking and data interpretation skills. These lessons raise awareness of real environmental issues and encourage pupils to think critically about sustainable solutions.

In addition, special attention within the framework of the pedagogical experiment was paid to the formation of students' research skills through the introduction of geographic information systems (GIS) into the educational process. The use of GIS technologies in geography lessons allowed students to conduct spatial analysis, work with cartographic material, and simulate real geographical processes, which significantly intensified their cognitive activity and research motivation.

Geographic Information Systems (GIS) can significantly enhance students' research skills in geography education. However, the effectiveness of this integration depends on specific pedagogical conditions that promote inquiry, critical thinking, and independent investigation. Key pedagogical conditions include student-centered, inquiry-based learning, which encourages students to ask geographic questions, gather and analyze data, and construct evidence-based arguments. Integrating GIS across the curriculum deepens students' understanding and connects skills to real-world issues. Authentic, contextualized learning experiences are essential for effective GIS-based research tasks. Case studies, fieldwork, and community-based projects using GIS allow students to experience the full research cycle, from planning and data collection to analysis, interpretation, and presentation. Developing technical and methodological skills is crucial for students, including the application of spatial analysis methods, data management, and interpretation of results in a research context. Teachers should provide clear guidance, access to relevant datasets, and structured opportunities for collaboration and reflection [24-26].

A supportive learning environment and resources, such as up-to-date GIS software and technical support, are essential for students to engage fully in research activities. Continuous assessment and feedback, including peer and self-evaluation, help students refine their research skills and deepen their understanding of the research process.

Multiple studies show that GIS-based teaching significantly improves students' spatial thinking, content knowledge, and research skills compared to traditional methods. Students engaged in GIS-supported research demonstrate higher achievement, motivation, and the ability to synthesize and analyze geographic information. Case studies confirm that authentic, inquiry-driven GIS projects foster greater mastery of research processes and prepare students for professional and academic challenges in geography and related fields [27].

Table 3.
Conditions conducive to the development of research skills in the use of GIS and digital technologies.

Pedagogical Condition	**Impact on Research Skills Development**
Inquiry-based, student-centered learning	Fosters questioning, investigation, and analysis
Integration of GIS across the curriculum	Connects skills to diverse geographic content
Authentic, contextualized projects	Increases engagement and relevance
Technical and methodological skill-building	Ensures proficiency in GIS tools and research methods
Supportive environment and resources	Enables effective, sustained research activities
Continuous assessment and feedback	Promotes critical reflection and skill refinement
Pedagogical Condition	Impact on Research Skills Development

Source: Bondarenko [24], Kerski [25], Demeuov, et al. [26], Mukhitdinova and Çiçek [27]

The formation of students' research skills in geography lessons using GIS technologies is most effective under pedagogical conditions that emphasize inquiry, authentic problem-solving, integration across the curriculum, and robust support and assessment structures. These conditions enable students not only to master GIS tools but also to think and act as geographic researchers, preparing them for future academic and professional pursuits.

Recent studies in Kazakhstan confirm that the integration of geospatial technologies into school geography enhances students' analytical competencies and reveals both pedagogical opportunities and infrastructural challenges [28, 29]. Moreover, digital innovations such as ChatGPT-4 are increasingly used to enrich field-based learning and excursion planning, supporting the development of applied geographic and research skills [30, 31].

4. Results and Discussion

4.1. Pre-Pedagogical and Practical Period

Students who have gained theoretical knowledge and learned how to develop an abbreviated periodic lesson plan go on to undertake pedagogical practice. Before attending, the students were surveyed. The results of the survey can be seen in the figures below.

Before the teaching practice began, students participated in preparatory seminars and workshops. These sessions aimed to deepen students' understanding of ecological concepts, critical thinking approaches, and the use of digital technologies, such as GIS. These sessions were crucial in preparing them to apply their theoretical knowledge in real classroom settings.

Students were also familiarized with the structure of modern geography and biology lessons, including how to integrate environmental topics and digital tools into teaching. Particular emphasis was placed on their ability to plan engaging and interesting lessons.

To assess their initial understanding and attitudes, a diagnostic survey was conducted. This survey aimed to encourage students to self-assess their environmental competencies and consider the importance of GIS in science education. The figures on the next page illustrate the results of this survey and provide an indication of the participants' background knowledge and level of awareness.

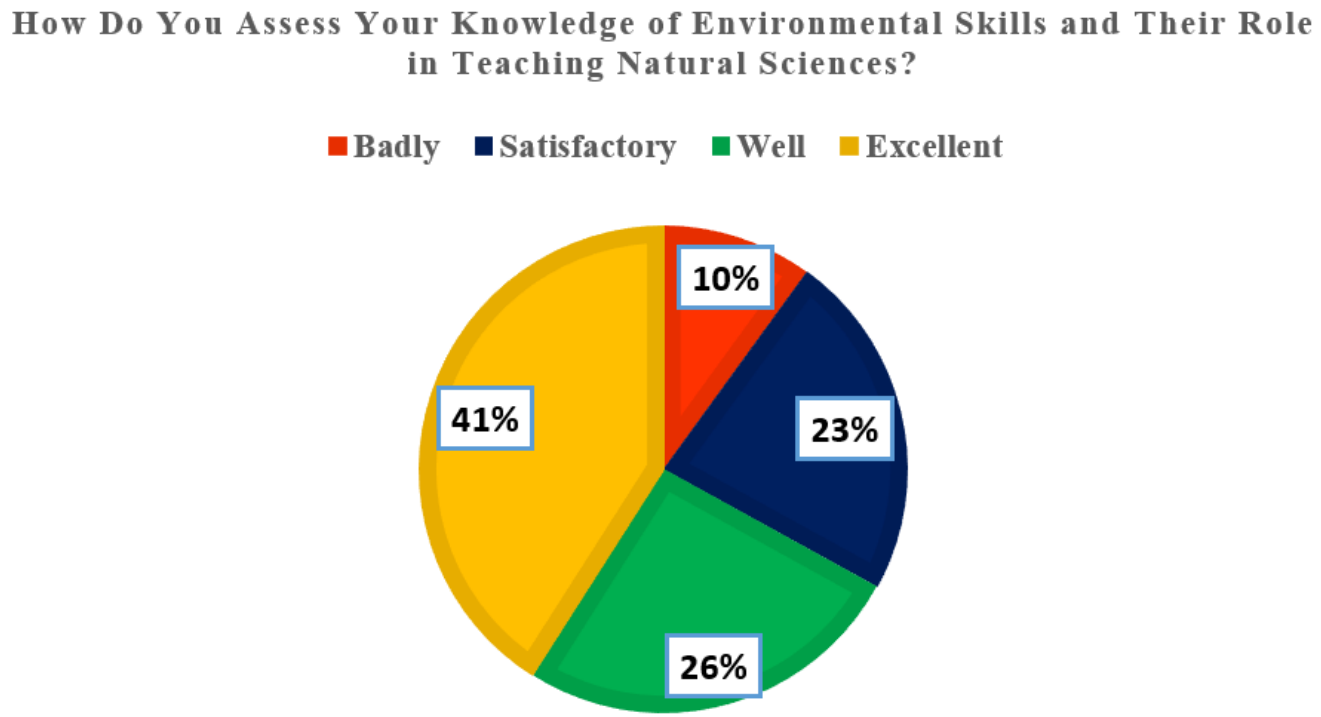

Figure 4.
Assessment of knowledge of environmental skills in science teaching.

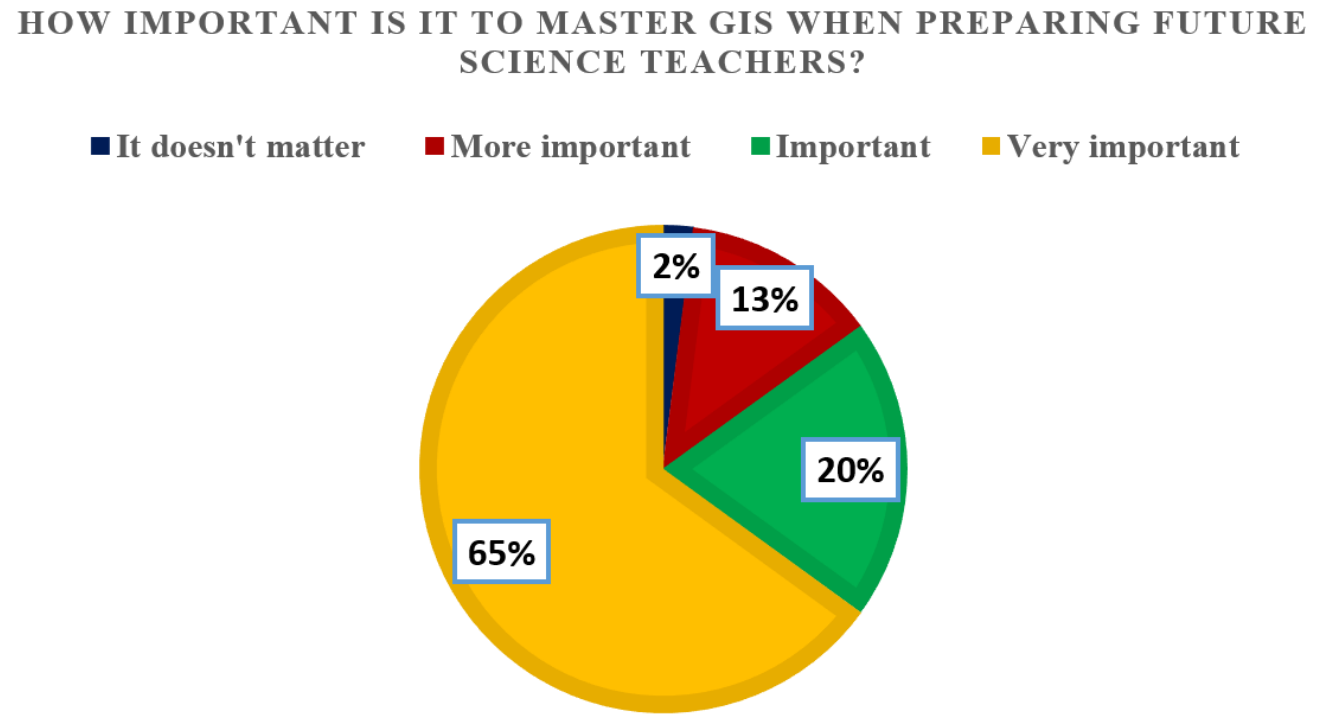

Figure 5.
The importance of GIS proficiency in training future science teachers.

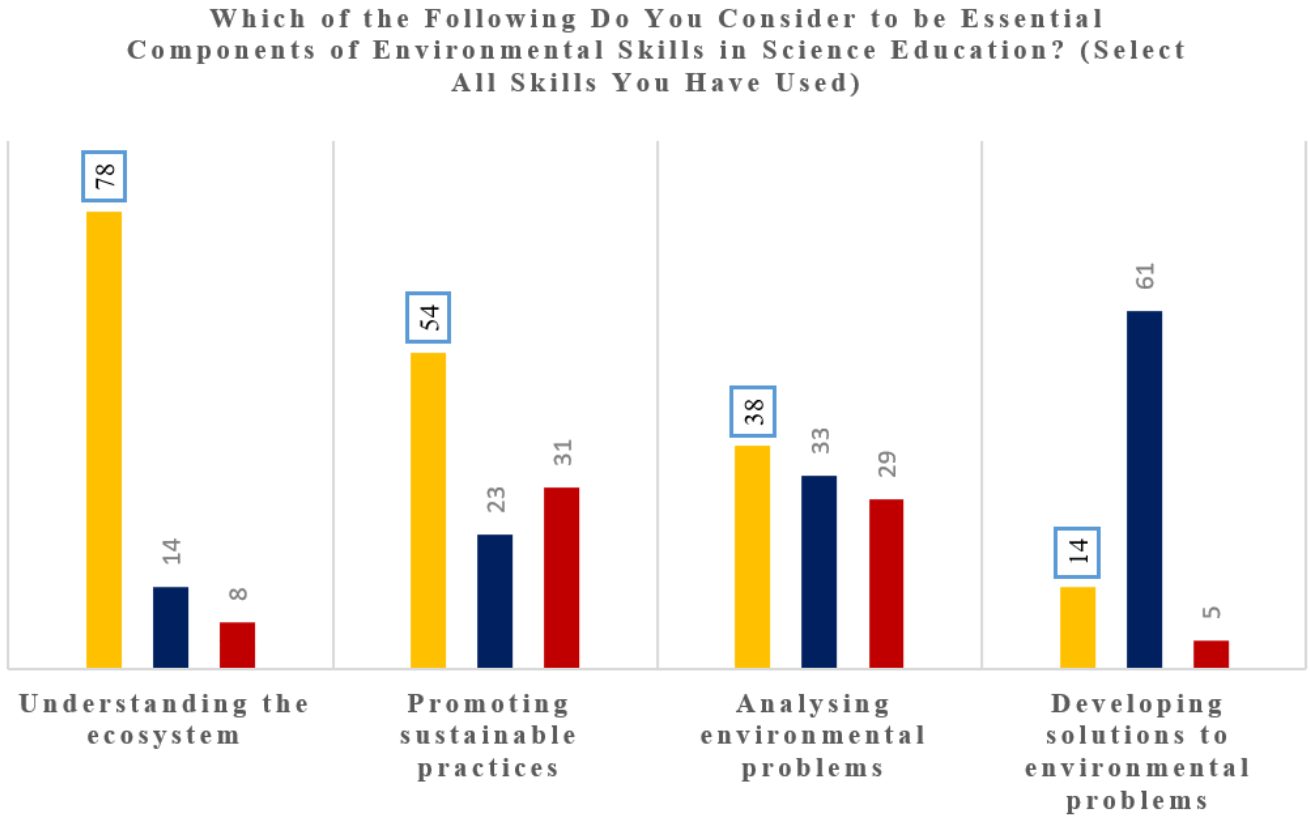

Figure 6.
Natural knowledge and environmental skills.

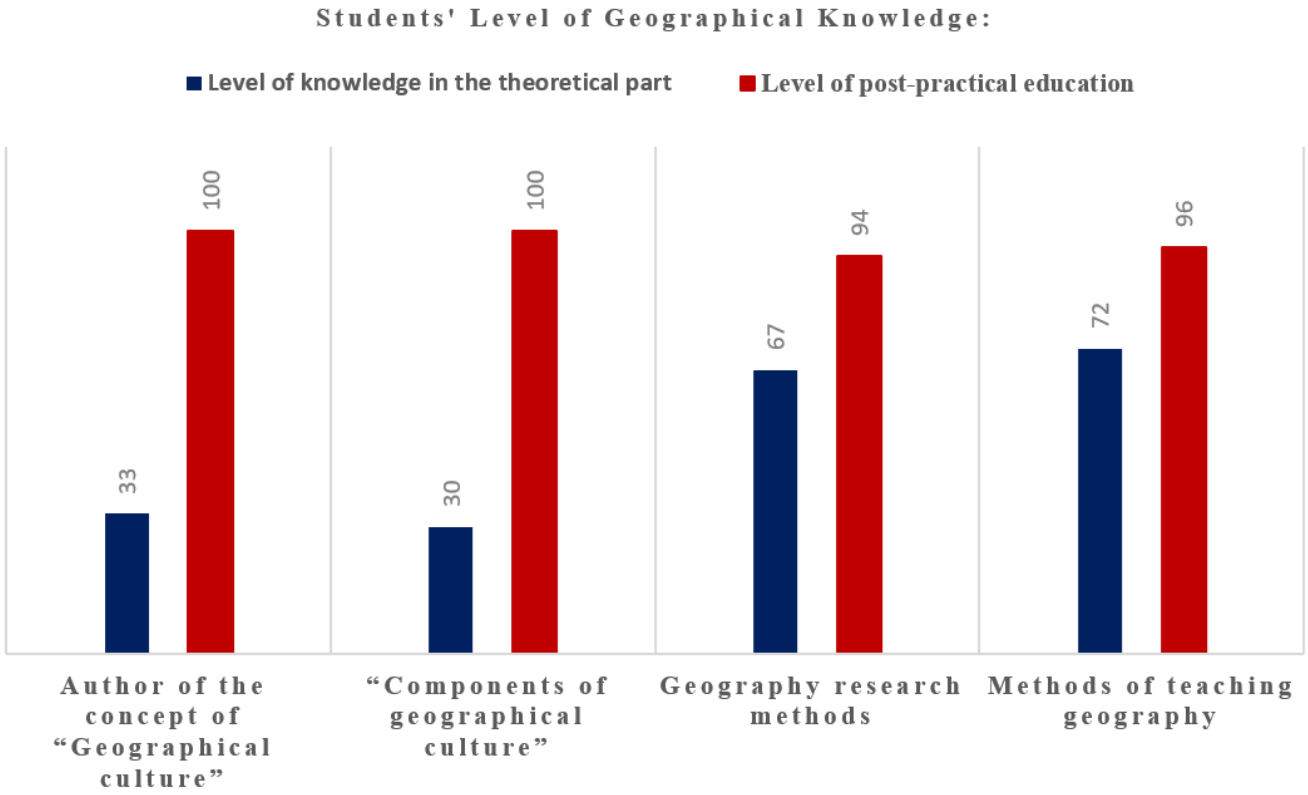

Figure 7.
Level of education of students.

According to the 'Environmental Skills and Understanding of Their Importance' section of the survey, 41% of the 76 respondents (31 students) rated their knowledge as "excellent," 21% (16 students) as "well," 23% (21 students) as "satisfactory," and 10% (8 students) as "badly." Regarding the importance of environmental skills, 65% of respondents (49 students) answered "very important," 20% (16 students) answered "more important," 13% (9 students) answered "important,"

and 2% (1 student) answered “it doesn’t matter.” Figure 5 shows that, based on the results, students are not yet ready for teaching experience, although many respondents answered “very important”, “more important”, “important”, or “it doesn’t matter”.

Figure 6 shows that, when asked questions in a covert manner, students' answers indicated that it is necessary to supplement their theoretical knowledge. However, Figure 7 shows that the “Level of knowledge in the theoretical section” of students increased from 33% to 100%, indicating that their geographical, biological, and pedagogical knowledge based on environmental skills is experientially prepared (ready to teach in school).

4.2. Pedagogical Experimental Stage of the Study

During the 'pedagogical practical stage' of the research, students applied their theoretical knowledge to teaching schoolchildren. Biology students conducted an experimental biology lesson for 9th grade students on ‘the impact of mining and pesticides on the environment and human health’ and ‘the greenhouse effect and thinning of the ozone layer’, as well as an experimental geography lesson on ‘designing environmentally friendly industries’ and ‘environmental problems in Kazakhstan’. Information about participants in the biology lesson in the experimental and control groups is presented in the formula below, where β denotes the students conducting the lessons (i.e., the experimental group) and α denotes the participants-observers labelled as the teacher:

$(9^{th}\ \text{grade} \times 3\beta) \times 3) = 9\beta$
$8^{а}\alpha + 11^{ə}\alpha + 7^{б}\alpha = 26\alpha$

Where a, B, b-classes “a”, “ə” and “б” of grade 9, “a” numbers 8, 11, 7 are the number of students in the control group. In the same report, students of the experimental group in geography were labelled with µ, observers with ñ:

$(9^{th}\ \text{grade} \times 3\mu) \times 3 = 9\mu$
$7^{а}ñ + 14^{ə}ñ + 9^{б}ñ = 32ñ$

The results for the two biology groups are shown in the figure below. According to the formula above, there are 37 biology students (9 + 26) and 41 geography students (9 + 32). A total of 78 students were considered for the experimental group, 18 for the control group, and 60 for the remaining group.

4.3. The Results of Pedagogical Experimental Classes

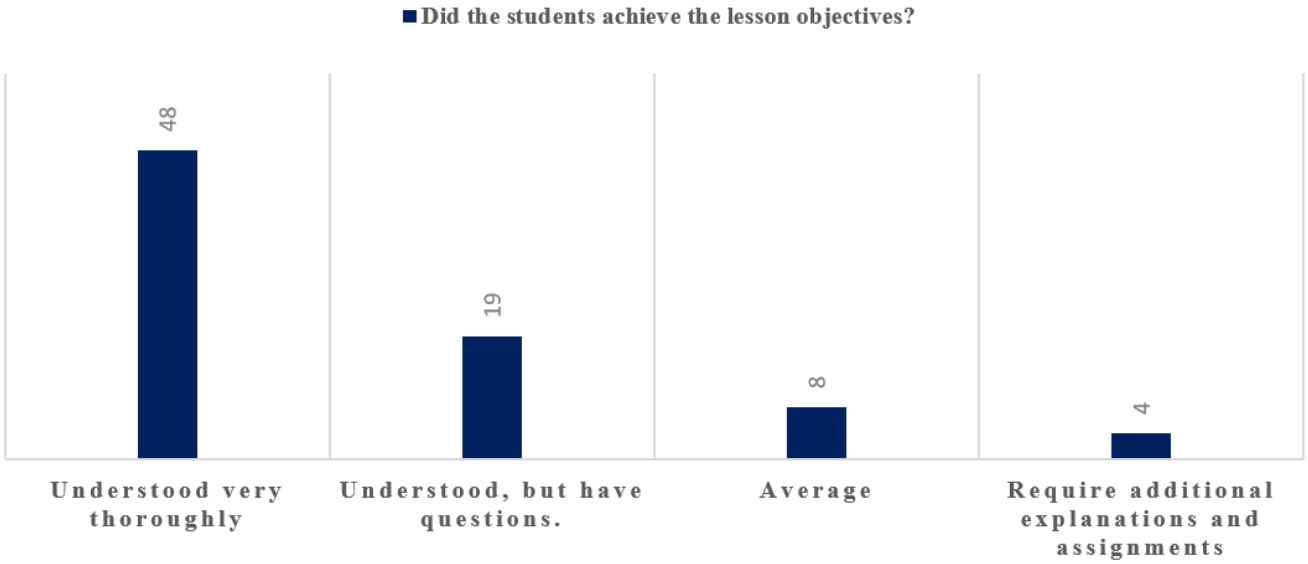

Figure 8.
Responses of the control group to the experimental lesson.

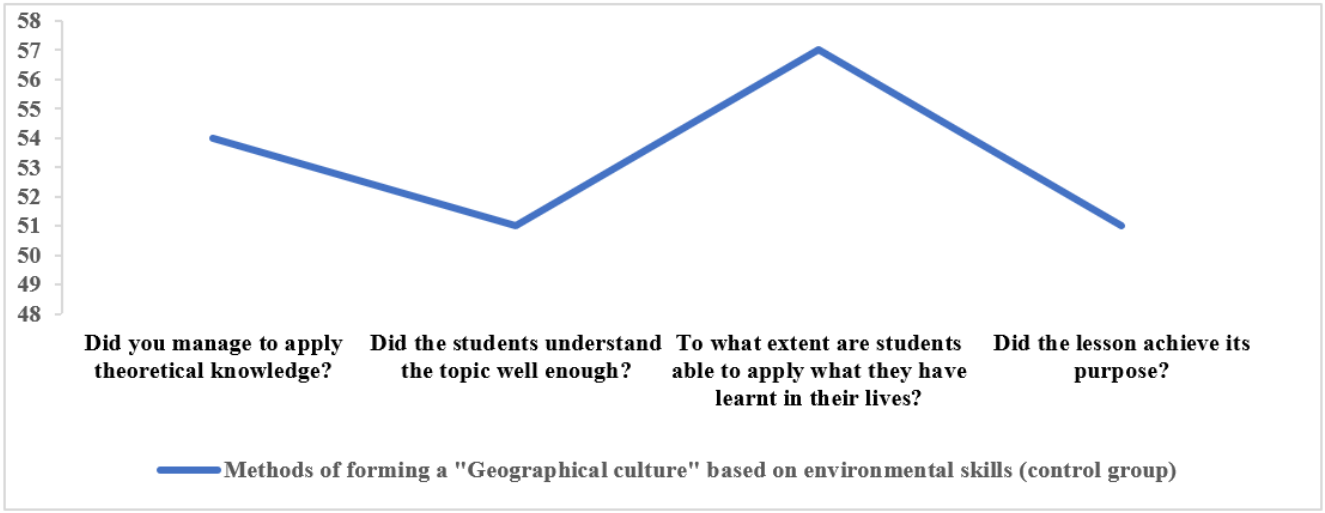

Figure 9.
Pupils' answers about the “lesson objective”.

For the biology lesson, as shown in Figure 8, students are asked, “Did the lesson objective achieve?” 48 students responded “Understood very thoroughly”, 19 students responded “Understood, but I have questions”, 8 students responded “Average” and 4 students responded ‘need more explanation’. ‘Average’ and “Require additional explanations and assignments” subtract the responses from the 79 students surveyed and calculate as shown below to derive a positive or negative result from the response of 67 students:

$$(67 \times 100) \div 79 = 84{,}8\%$$

84,8% can be evaluated as ‘very good’ if we assume an 85% approximation.

“Did you manage to apply the theoretical knowledge?” was asked to the question 54 students, “Did the students understand the topic well enough?” 51 students, “To what extent are students able to apply what they have learnt in their lives?” 57 students, and “Did the lesson achieve its purpose?” 51 students answered the question. The average score is (54+51+57+51)/60=53/60 (88%). The results of practical lessons of biology students can be evaluated on average by 87% (85+88)/2, i.e., “excellent”.

Exactly, by this method, practical classes for students-geographers on the topic “Design of ecologically clean production and ecological problems of Kazakhstan” were conducted, divided into experimental and control groups. It was calculated in the same way as above and evaluated at 79%.

5. Conclusion

The study confirmed that developing environmental literacy is an effective approach to forming students' geographical culture in pedagogical practice. Biology and geography lessons enabled the level of material assimilation and application of knowledge to be assessed.

Analysis of biology lessons showed that 84.8% of students achieved the lesson objective and that the average score for practical tasks was 87%, corresponding to a high grade of 'excellent'. Students' practical lessons in geography, conducted using a similar methodology, achieved an average score of 79%, assessed as ‘good’. Thus, the presented pedagogical methods contribute to the effective assimilation of the material and enhance students' geographical literacy.

Particular attention was paid to integrating ecological literacy into the education of future biology and geography teachers. Developing the ecological literacy of students of natural science specialties directly affects their conscious attitude towards the environment and geographical culture.

6. Recommendations

- For university teachers: introduce practical tasks aimed at developing the environmental literacy of future biology and geography teachers.
- For school teachers, the active application of an interdisciplinary approach combining ecological knowledge with the teaching of geography and biology is recommended.
- For educational institutions: develop and implement professional development courses for teachers on modern methods of geographical and cultural formation through environmental education.
- For future teachers, pay special attention to developing environmental competence and search for innovative teaching methods to increase students' interest in ecology and geography.
- For researchers in the field of pedagogy, continue studying effective methods of forming geographical culture, taking into account modern educational technologies and trends.
- At all levels of education, teach modern approaches to analyzing and solving environmental problems by integrating geographical information systems (GIS) into the educational process.

The developed pedagogical methods can then be implemented in university and school curricula to improve the training of future natural science teachers and their ability to effectively foster geographical awareness through environmental

education. Using GIS technologies provides additional opportunities for developing the digital and research competencies of future teachers.

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