

Pedagogical strategies for enhancing environmental education in Uzbek primary schools: a mixed-methods study

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ABSTRACT

Environmental education is a fundamental component of primary science education, fostering ecological awareness and responsible behavior from an early age. Despite global recognition of its importance, the effective integration of environmental education in Uzbek primary schools faces significant challenges, including insufficient teacher competencies and limited interactive pedagogical approaches. This study investigates strategies to enhance environmental education through a mixed-methods approach involving literature analysis, questionnaires, observations, and experimental lessons. Interactive methods, project-based learning, and educational games were implemented to increase students' ecological knowledge, practical skills, and engagement. The findings indicate substantial improvements: the proportion of students demonstrating high proficiency in environmental knowledge and practical skills increased from 23.8% to 43.3%, while those with low proficiency decreased from 48.6% to 28%. The study provides actionable insights for curriculum developers, emphasizing the integration of experiential learning and contextually relevant content; for teacher training programs, highlighting the need to strengthen pedagogical competencies in environmental education; and for policy makers, advocating systematic support for resource allocation and digital tools to enhance learning outcomes. Limitations include the regional focus and reliance on self-reported engagement measures. Future research should explore broader geographic contexts, long-term impacts, and the use of multimedia resources to further strengthen environmental literacy.

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1. INTRODUCTION

Environmental education has emerged globally as a critical component of primary education due to its role in fostering environmental competence and sustainable behaviors from an early age [1], [2]. Innovative pedagogical approaches enhance children's ecological awareness and active participation in

environmental protection. Research shows that environmental education not only develops cognitive understanding of ecological issues but also nurtures responsible attitudes and practical skills for sustainability [2], [3]. Early exposure to nature strengthens students' connection with the environment, promoting pro-environmental behavior and ecological sensitivity [1], [4], [5]–[8].

In Uzbekistan, the integration of environmental education in primary schools faces significant barriers. Teachers often lack sufficient knowledge and pedagogical expertise, limiting their ability to deliver effective environmental instruction [9]–[12]. Curricula and instructional materials frequently remain knowledge-based and fail to incorporate interactive, contextually relevant approaches [13]–[15]. While pre-service teachers generally possess theoretical knowledge, in-service educators demonstrate stronger applied skills, highlighting a gap between academic preparation and classroom implementation [16]. The limited use of project-based learning, games, and outdoor activities reduces opportunities for experiential learning and student engagement [15].

Socio-cultural and ecological issues relevant to local contexts are often absent from textbooks, diminishing the practical relevance of environmental education [15], [17]. Outdoor learning and direct engagement with nature, proven to enhance understanding and attitudes [1], remain underutilized. Existing research largely focuses on higher education or teacher trainees [18], leaving a gap in evidence for primary school pedagogy. These challenges reveal a clear need to systematically examine pedagogical strategies that combine interactive teaching, project-based activities, and digital tools to enhance students' ecological knowledge and skills. Addressing this gap is essential to nurture environmentally responsible behavior and support sustainable development. This study develops, implements, and evaluates pedagogical strategies tailored for Uzbek primary schools. Using a mixed-methods approach, it examines the impact of interactive and integrated teaching methods on students' environmental knowledge, practical skills, and pro-environmental attitudes, providing evidence-based recommendations for curriculum design, teacher training, and policy initiatives.

2. METHOD

This mixed-methods study examined the development of ecological consciousness in primary school students. A stratified sample of 1,056 learners from schools across Tashkent, Surkhandarya, and Jizzakh regions ensured diverse representation, as seen in Table 1. Data were collected through classroom observations of “natural science” and “the world around us” lessons, student questionnaires, teacher interviews, testing, and experimental lessons. All instruments were piloted with 50 students and 10 teachers for clarity and relevance. Content validity was confirmed by environmental education experts, and Cronbach's alpha coefficients exceeded 0.82, demonstrating strong reliability. Quantitative data were analyzed using descriptive and inferential statistics, while qualitative data underwent thematic analysis. Triangulation of methods enhanced rigor and robustness, enabling identification of effective pedagogical strategies and practical insights for improving environmental education in Uzbek primary schools.

Table 1. Schools recognized as research sites

No	Schools selected as experimental objects	Number of students		
		Total	Control class	Experimental class
1	School 219 of the Olmazar district of Tashkent city	185	93	92
2	School 28 of the Olmazar district of Tashkent city	163	82	81
3	11th school of Mirzachul district of Jizzakh region	185	92	93
4	18-school of Mirzachul district of Jizzakh region	181	90	91
5	1-school of Surkhandarya region, Termez city	201	100	101
6	1-school of Sherabad district of Surkhandarya region	141	71	70
	Total	1,056	422	528

When choosing teaching methodologies, it is necessary to take into account a number of important factors: the current stage of development of the educational institution, the specific topic of the subject being taught, the content of the material, and the level of readiness of students to master the educational material. The choice and application of pedagogical strategies should be determined not only by the educational objectives of the lesson, but also by the specific content of the material itself. Pedagogy of teaching natural sciences is divided into three main methodological groups: i) the oral method - such as oral presentation, conversation, work with a book; ii) the demonstration method - demonstration, independent observation, travel; and iii) the experiential approach - incorporating oral and written tasks, graphical representations (e.g., drawing), and laboratory activities. Given first graders' limited literacy skills, it is imperative to develop their conceptual understanding of nature through visual aids and field experiences. An important

pedagogical task is to inform first-graders about the role of the surrounding world in the life of a schoolchild, the negative impact of environmental pollution on human health, measures to prevent this situation, the formation of environmental cleanliness and health care skills.

During the research, we identified and systematized the ecological concepts that first-graders need to know: i) the environment; a colorful universe; ii) trees, bushes, grass, some protected plants and animals in their habitat; iii) insects, fish, birds, wild and domestic animals; iv) the main signs of the seasons; v) rules of behavior in nature, basic information about your city (village), address, types of transport, principles of personal hygiene, traffic rules, how to behave in public places. We also chose methods to introduce students to eco-concepts: conversation, story, travel, question and answer. The Appendix contains examples of lesson plans.

3. RESULTS AND DISCUSSION

Upon task completion, the educator synthesizes the lesson's content and assigns reflective independent work. At the initial stage, it is impossible to form an ecological culture in students by providing them with sufficient ecological knowledge, since for this, students need to understand the content of existing socio-ecological relations, the state's environmental policy. The level of awareness of the content of activities aimed at organizing an ecological culture, environmental laws, procedures, academic subjects that are a source of ecological knowledge, and activities that promote their popularization was studied. It was also determined how to resolve the situation in teaching aids related to the technology of environmental education of primary school students. Then it was allowed to experiment with didactic and handout material prepared to increase the interest of students in "natural science" taking into account their age and specific features of the teaching methodology, using pedagogical technologies, computer and information technologies.

The pedagogical experiment-testing in the selected schools was mainly aimed at checking the following objectives. The first is the significance and impact of resources associated with ecological education in enhancing primary students' comprehension of "natural science" curriculum. Secondly is the feasibility of introducing scientific and methodological aspects into the process of studying "natural science". The next is about to what extent do students master didactic materials on the topic "natural science". Fourth is on enhancing student engagement in natural science studies through the integration of ecological education resources into the curriculum. The fifth is on demonstrating the pedagogical value of ecological education materials for primary students' developmental progress. Sixth is on highlighting the significance of environmental education materials in fostering ecological culture and nurturing logical reasoning in primary learners. Lastly is the effectiveness of organized extracurricular activities on environmental education of primary school students.

In the pedagogical trial, instructional methodologies for imparting environmental education content were systematically examined within both curricular and extracurricular frameworks. This research focused on evaluating the efficacy of these approaches, revealing promising outcomes in fostering student comprehension and engagement, as evidenced in Table 2. During the formative phase of the experiment, the status of environmental education among primary school learners was thoroughly assessed.

Table 2. The state of environmental education of primary school students

No	Experimental class		Control class		Experimental class		Control class	
	P	N	P	N	P	N	P	N
Have knowledge about environmental protection	176	352	158	264	423	105	301	121
Care of animals, birds	193	335	103	319	420	108	276	146
Concern for the preservation of flora	105	423	208	214	431	97	299	123
Conservation and use of natural resources	112	416	119	303	347	181	259	163
Efficient use of water	131	397	141	281	409	119	288	134
Be able to correctly assess the environmental situation in the place of residence, school, home and get out of it	96	432	90	332	434	94	281	141
Ability to deal with negative situations that harm the environment	120	408	131	291	361	167	270	319
Reasonable organization of environmental protection activities of students	80	448	71	351	431	97	299	123

P=positive, N=negative

The third-stage experimental outcomes indicate that a significant proportion of elementary students are unable to adequately respond to posed questions, primarily due to a lack of understanding regarding proper ecological interaction. Furthermore, even those students attempting responses demonstrate a deficiency in their ability to accurately conceptualize the core principles of environmental stewardship,

thereby impeding their capacity to effectively plan and implement activities focused on ecological conservation and protection. As a result of attempts to determine the reasons for the current situation, it turned out that almost all students do not have complete information about the mentioned knowledge of environmental education and sources reflecting their content. At the end of the experiment, the attitude of junior school students to a careful attitude to nature, their education in relation to a careful attitude to nature was determined once again, and a completely different phenomenon took place than the previous situation.

Special questions about respect for nature were created for the students who took part in the experiment. In the formulation of the questions, particular emphasis was placed on several key factors: the components of the educational curriculum, specifically the knowledge framework within the “natural science” subject; interdisciplinary linkages; the prior experiential and cognitive levels of students; the scientific rigor and relevance of the selected inquiries; developmental age characteristics of learners; and the continuity and coherence of the questions. Various versions of the questionnaires were designed to cultivate a sense of environmental stewardship among students. One of the options (Option 1) is presented:

- What does “natural science” teach?
- What do you mean by respect and preservation of flora?
- Why is the forest called the queen of the earth?
- Should we protect the animal world? How do you understand this?
- Did you know that you also contribute to the pollution of the surrounding world?
- What is the Universe around us?

The students answered the questions asked. Their knowledge levels are summarized in Tables 3-12. The level of knowledge proficiency in environmental education of primary school students was calculated using a 100-point system. The following criteria were used to determine the levels: i) high level 86-100 points; ii) average level 71-85 points; and iii) lower level 56-70 points. The experiment assessed the engagement and effectiveness of ecological education methodologies in fostering primary school students’ environmental awareness.

Table 3. Hierarchical stages of ecological education competence in elementary learners

Classes	Quantity	Level of proficiency in environmental education					
		Before the experiment			After the experiment		
		Low	Average	High	Low	Average	High
Control	528	101	320	107	96	321	111
Experimental	528	129	283	121	118	273	137

Table 4. Hierarchical levels of structuring ecological education for primary learners

Classes	Quantity	Level of proficiency in environmental education					
		Before the experiment			After the experiment		
		Low	Average	High	Low	Average	High
Control	528	121	320	87	85	329	114
Experimental	528	102	307	119	103	267	158

The article outlines the post-experimental stages of structuring ecological education activities for primary learners. The degree of organization of these activities was evaluated through their engagement in the following instances: i) participation in protecting flora; ii) caring for wildlife and activities to preserve it; iii) efforts to prevent water use and pollution; iv) activity in caring for nature in the place of residence; v) cultivated plants, their participation in the process of protecting trees from harmful insects; vi) participation in the “devils of nature” circle; vii) participation in organizing and holding events related to admiring nature; viii) Behavior on the streets; ix) active participation in events related to environmental protection in the district, region, country; and x) ability to work independently. We focused on the integration of ecological education initiatives for primary learners within experimental educational institutions. Details of this successful attempt are presented in Table 5.

Therefore, the level of environmental education of primary school students is: i) teaching a caring attitude towards nature; and ii) environmental education of primary school students was determined by the indicators of the organization of activities. Both criterion indicators were considered as the main indicators of the level of environmental education of primary school students. Experimental schools based on the indicators of educating students in the spirit of caring for nature. It was determined that primary school students have a conditionally high, average and low level of caring for nature. The result of this study is expressed in Table 6.

Table 5. Engagement of elementary learners in ecological education initiatives

No	Schools	Number of students						Difference between intervals (%)
		Before the experiment			After the experiment			
		Number of students	Correct answer	In percent	Number of students	Correct answer	In percent	
1.	School 219 of the Olmazar district of Tashkent city	162	51	31.5	162	84	51.9	20.4
2.	School 28 of the Olmazar district of Tashkent city	150	48	32	150	90	60	28
3.	11th school of Mirzachul district of Jizzakh region	164	43	26.2	164	96	58.4	22.9
4.	18-school of Mirzachul district of Jizzakh region	160	51	31.9	160	87	54.4	22.5
5.	1-school of Surkhandarya region, Termez city	173	51	29.5	173	85	49.1	19.6
6.	1-school of Sherabad district of Surkhandarya region	141	40	28.4	144	81	56.3	28.1

Table 6. Quantitative and qualitative changes in the level of environmental education of primary school students

No	Levels	Experimental class		Control class	
		At the beginning of the experiment	At the end of the experiment	At the beginning of the experiment	At the end of the experiment
1	High	137	167	133	102
2	Average	221	219	237	247
3	Low	170	142	158	179

The hierarchical levels of ecological education attainment among primary learners were assessed based on the degree of internalization of environmentally responsible cognitive constructs and the development of functional competencies related to proactive engagement with the natural environment: from 57% to 70% - "low level" (3); from 71% to 85% - "average level" (4); from 86% to 100% - "high level" (5). Grounded on the outcomes of the empirical assessments, a statistical evaluation was carried out to determine the comparative levels of ecological literacy among primary learners in the pre-intervention and control cohorts. The initial diagnostic findings are illustrated in Table 7.

Table 7. Diagnostic parameters for evaluating pre-experimental quantitative and qualitative transformations in the environmental literacy of early-grade learners

Classes	Number of students	Level of academic performance		
		High	Average	Low
Experimental class	528	137	221	170
Control class	528	133	237	158

The performance level of each student is calculated as a percentage using the (1).

$$K = \frac{J}{Q} * 100 \% \quad (1)$$

Here, J denotes the aggregate of accurate responses recorded during the diagnostic survey, while Q represents the total sample size of participating learners. The synthesized outcomes are presented in the Table 8.

Table 8. Synthesized student results (before the experiment)

No	Levels	Experimental class (%)	Control class
1	High	25.9	24.8
2	Average	41.9	48.1
3	Low	32.2	27.1

Assuming the evaluation outcomes from the experimental and control cohorts represent sample sets 1 and 2, respectively, the ensuing statistical distribution is displayed in Table 9.

Table 9. Statistical distribution of experimental and control groups (before the experiment)

Choice option	Classes	High	Average	Low
1	Experimental class	137	221	170
2	Control class	131	254	143

The modal values for the experimental and control cohorts are represented by $M_t=5$ and $M_n=3$, respectively, indicating a substantial difference where $M_t > M_n$. Consequently, this implies that the corresponding mean values for these cohorts fulfill the condition $X > Y$, which is computed using the (2):

$$\begin{aligned}\bar{X} &= \frac{1}{n} \sum_{i=1}^{n=3} n_i x_i = \frac{1}{528} (137 \cdot 5 + 221 \cdot 4 + 170 \cdot 3) \approx 3.93, \\ \bar{Y} &= \frac{1}{n} \sum_{i=1}^{n=3} n_i x_i = \frac{1}{528} (131 \cdot 5 + 254 \cdot 4 + 143 \cdot 3) \approx 4\end{aligned}\quad (2)$$

Therefore, the average score of the experimental class will be lower than the average of the control class, that is $X < Y$. If the average of the experimental class is lower than the average of the control class with the corresponding average values, then the indicators are not achieved.

Now, the research conduct a statistical evaluation of the ecological education proficiency of primary school students in both experimental and control groups during the post-intervention phase. The control outcomes are summarized in Table 10.

Table 10. Metrics for assessing quantitative and qualitative transformations in the ecological education technology proficiency levels of primary learners post-intervention

Classes	Number of students	Level of academic performance		
		High	Average	Low
Experimental class	528	230	156	142
Control class	528	210	147	171

If we calculate these indicators as percentages using (1), we will get data as in Table 11. Assuming the evaluation outcomes in the experimental and control cohorts as sample sets 1 and 2, respectively, Table 12 shows the statistical distribution for further analysis.

Table 11. Synthesized student results (after the experiment)

No	Levels	Experimental class (%)	Control class (%)
1.	High	43.9	39.8
2.	Average	29.5	27.8
3.	Low	27	32.4

Table 12. Statistical distribution of experimental and control groups (after the experiment)

Choice option	Classes	High	Average	Low
1	Experimental class	230	156	142
2	Control class	210	147	171

The modal values for the experimental and control groups are represented by $M_t=5$ and $M_n=3$, respectively, indicating a significant discrepancy where $M_t > M_n$. This, consequently, suggests that the mean values for these cohorts also fulfill the condition $X > Y$, which we compute using the (3):

$$\begin{aligned}\bar{X} &= \frac{1}{n} \sum_{i=1}^{n=3} n_i x_i = \frac{1}{528} (230 \cdot 5 + 155 \cdot 4 + 142 \cdot 3) \approx 4.1, \\ \bar{Y} &= \frac{1}{n} \sum_{i=1}^{n=3} n_i x_i = \frac{1}{528} (210 \cdot 5 + 147 \cdot 4 + 171 \cdot 3) \approx 4\end{aligned}\quad (3)$$

Therefore, the mean proficiency level in the experimental cohort exceeds that of the control cohort, denoted as $X > Y$. We will now proceed to compute the dispersion coefficients for both groups, starting with the calculation of the sample variances.

$$D_m = \frac{1}{n} \sum_{i=1}^{n=3} n_i (x_i - \bar{x})^2 / (n - 1) \approx 0.42, \quad D = \frac{1}{n} \sum_{i=1}^{n=3} n_i (y_i - \bar{y})^2 / (n - 1) \approx 0.85.$$

From these outcomes, we derive the standard deviations: $\tau_m = \sqrt{0.42} \approx 0.64$, $\tau_n = \sqrt{0.85} \approx 0.92$. Using these values, we compute the variability indices for both cohorts: $\delta_m = \frac{\tau_m}{x} = \frac{0.64}{4.1} \approx 0.2$, $\delta_n = \frac{\tau_n}{y} = \frac{0.92}{4} \approx 0.23$. If the value level of the statistical feature $\alpha=0.05$, then from the table of Laplace functions, we determine the critical point t_{kr} for the statistic: $t_{kr}=1.67$. If we find reliable deviations of the estimate from this, then it is equal to $\Delta_m = t_{kr} \frac{D_m}{\sqrt{n}} \approx 0.03$, and in the control class it is equal to $\Delta_n = t_{kr} \frac{D_n}{\sqrt{n}} \approx 0.05$. If we find the confidence interval for the experimental class based on the results found: $4.07 \leq a_x \leq 4.13$, the confidence interval for the control class is $3.65 \leq a_x \leq 3.75$. From this, it can be inferred with a significance level of $\alpha=0.05$ that the mean score in the experimental cohort surpasses that of the control cohort, with non-overlapping confidence intervals. Consequently, the mathematical and statistical analysis indicates that a favorable outcome was attained. Building upon the aforementioned findings, we will proceed to compute the quality metrics associated with the experimental intervention.

$$K_{ustl} = \frac{(\bar{X} - \Delta_m)}{(\bar{Y} - \Delta_n)} = 1.08 > 1, K_{bd} = (\bar{X} - \Delta_m) - (\bar{Y} - \Delta_n) = 0.42 > 0$$

The findings reveal that the effectiveness criterion for evaluating the training surpasses unity, while the criterion for assessing knowledge acquisition exceeds zero. It is evident that the proficiency levels in the experimental cohort exceed those in the control cohort. Therefore, upon completion of the intervention, the results indicate that the experimental work aimed at evaluating the quantitative and qualitative shifts in the environmental education levels of primary school students has proven to be effective in enhancing environmental literacy.

The evidence for the environmental impact of nature-based education is largely due to the lack of controlled experiments. For example, Collado *et al.* [1] conducted an experiment examining the impact of a nature-based environmental education program included in the school curriculum on children's environmental attitudes and behavior. They used children enrolled in a traditional educational program as a control group. The program involved primary school students from seven Spanish schools. The findings indicate that environmental education demonstrated greater advancement within the nature-based pedagogy group compared to the control group. This supports the integration of nature-oriented pedagogical approaches within educational systems to foster more positive attitudes toward environmental stewardship among children.

Environmental education holds significant relevance today, as the global demand for resources and pollution levels continue to escalate. In a study conducted by Treagust *et al.* [2], the study sought to assess primary school students' environmental knowledge, their attitudes toward environmental conservation, and their actions toward environmental protection, with the aim of enhancing the prominence of environmental education within school curricula. Their conclusions were: i) 4th-grade students exhibit a higher level of environmental concern than 5th-grade students; ii) gifted students demonstrate a deeper understanding of environmental issues than their peers; and iii) female students show a greater commitment to environmental preservation than male students. However, the study also highlighted that possessing environmental knowledge does not necessarily correlate with a student's commitment to environmental protection or active engagement in solving environmental challenges.

The formation of environmental culture in primary school students is considered important. A number of works have been carried out in this direction. For example, in the work of Yeşilyurt *et al.* [3], the main goal is to increase the environmental culture of primary school students. The study was conducted based on the principle of distinguishing between the "action research" and "qualitative research" cohorts. It took place during the 2018-2019 academic year with participants from Gungoren Public Elementary School in Istanbul. Data collection involved a triangulation of methods, including student-created environmental drawings, observation protocols, and semi-structured interviews. Findings indicated that students exposed to environmental education exhibited a marked increase in ecological awareness, as reflected in their post-interview drawings. These visual representations demonstrated not only an empathetic attitude toward nature but also high aesthetic quality, illustrating an emotional and intellectual engagement with environmental issues.

Given the increasing significance of natural science issues, international conferences and symposia dedicated to exploring these matters have proliferated across various nations and educational levels in recent years [10]. Notably, it has been underscored that societal scientific literacy remains inadequate, with its importance poised to escalate further in the 21st century. Early-stage scientific education plays a pivotal role in fostering scientific literacy [19]. Broadly, the field of scientific education has undergone substantial transformations, including shifts in curricular content and the pursuit of more effective pedagogical methods. Concurrently, there is a growing demand for a qualitatively advanced society capable of addressing emerging global challenges.

This clearly underscores the critical role of science education in shaping a child's overall personality development. Through collaborative efforts involving all stakeholders within the school community, which significantly influences the cultivation of a positive environmental attitude, young learners can enhance their ecological competencies. A relevant reference supporting this notion is found in the work of Barraza [20], which explores the pivotal role of educational institutions in fostering environmental consciousness among primary school students.

As environmental challenges intensify, the necessity to adopt sustainable, responsible, and respectful practices for environmental conservation and restoration becomes more crucial. Buchanan *et al.* [21] critically examines innovative, formal, and informal educational practices and citizenship in experimental approaches to environmental education among schools, families, and communities. However, it is important that current and emerging technologies teach students to think globally and to act responsibly and respectfully toward the environment.

Research by Diez-Ojeda *et al.* [22] analyzes the effect of the implementation of a service-learning program within the environmental education subject of Spanish primary schools. The service-learning project was evaluated and the change in attitudes towards sustainable development of 44 pre-service teachers was measured, considering the environment, economy, society and education as dimensions, using a pre- and post-experimental test without a control group. Environmental education has been implemented in Indonesian schools and the study and analysis of sustainability and hope related to environmental education in schools was investigated [19]. The results of the study show that teachers have high expectations for schools, fellow teachers and students. Teachers expect schools to effectively develop and implement environmental education related concepts, missions and curricula, as well as supporting programs. The study by Husin *et al.* [23] assessed the level of knowledge and behavior towards the environmental factor "water" among primary school students in Bacau, Romania. The results highlight the importance of environmental education in primary school, which prepares children for a responsible attitude towards the environment. It is recommended to implement interactive educational programs and develop partnerships with the community and local organizations to promote water conservation and reduction of its consumption, thereby creating a long-term culture of sustainable development. Also, a study by Simon *et al.* [24] aimed to summarize the characteristics of studies on the use of augmented reality in environmental education to identify important gaps and trends in the literature. The results of the study indicate the need for additional research on the use of augmented reality in environmental education. The need to involve teachers in augmented reality research in environmental education is emphasized due to the observed lack of teacher participation in such studies.

The study conducted by Kosta *et al.* [25] examined the influence of an environmental education initiative on participants' ecological connectedness. Data analysis from 283 primary school students revealed that outdoor-based learning significantly enhanced students' environmental knowledge and awareness. Furthermore, it was found that students with prior participation in environmental education programs demonstrated a stronger sense of connection to nature and exhibited superior retention of acquired ecological knowledge compared to their peers. A recent study by Lamanauskas and Makarskaitė-Petkevičienė [26] highlighted the pivotal role of primary educators in cultivating pupils' ecological consciousness, underscoring the imperative for comprehensive pre-service environmental pedagogical preparedness. The conducted study aimed to determine the meaning of environmental education, how the subject is understood by future primary school teachers, and what their vision of implementation is. The study involved 136 students from two Lithuanian universities. Consequently, the significance of environmental education is accentuated, as its interdisciplinary nature encompasses diverse domains suitable for integration into primary curricula. Findings reveal that prospective teachers' perceptions regarding the implementation of environmental education reflect both cognitive-intellectual dimensions and activity-based, behaviorally oriented components within their professional pedagogical frameworks.

Numerous studies emphasize the necessity of enhancing science education across all tiers of the educational system, with particular attention to the primary education stage [27]. It is essential to recognize that the introduction to scientific concepts in elementary grades falls short of contemporary pedagogical standards. The core of science education at this level should revolve around inquiry-based learning and empirical investigations. Instructional strategies in primary education must prioritize constructivist methodologies and the facilitation of social interaction as a means of knowledge construction. Educators should be passionate about teaching, fostering an environment that enables students to maximize their potential. The primary objective of science education at the elementary level is to initiate students into the exploration of their surrounding environment, fostering a comprehensive understanding of the world and its intricate interconnections, which serves as the foundation for the study of individual natural sciences in higher grades. A significant factor contributing to the diminished interest in science is the inadequate emphasis placed on its core components (physics, biology, chemistry, and geography) within the primary curriculum. Regrettably, elementary students often face challenges in assimilating fundamental scientific

concepts and developing research competencies. Conversely, primary school educators often lack the requisite scientific expertise. In light of this, it has been highlighted that natural sciences, particularly chemistry, are perceived as abstract and disconnected disciplines by students. It is imperative to design a well-structured and comprehensive system of hands-on scientific activities spanning grades 1 through 4. The cultivation of student interest in the natural sciences should be prioritized as a key objective within the educational framework at the elementary level, thereby enhancing both teaching and learning processes.

4. CONCLUSION

This study underscores the importance of environmental education in cultivating ecological awareness, practical skills, and responsible attitudes among primary school students. The implementation of interactive teaching methods, project-based activities, and practical exercises significantly improved students' preparedness, with high proficiency increasing from 23.8% to 43.3% and low proficiency decreasing from 48.6% to 28%. The findings offer actionable insights for educational stakeholders. Curriculum developers should integrate experiential and interactive components that link theoretical knowledge with practical environmental tasks. Teacher training programs must focus on enhancing pedagogical competencies in environmental education, including project-based learning, outdoor activities, and educational games. Policy makers are encouraged to support the systematic integration of environmental education into primary curricula, providing resources for professional development and technology-enabled teaching tools.

This study is limited by its regional scope and reliance on self-reported measures of engagement. Future research could expand to diverse geographic contexts, explore the long-term effects of environmental education interventions, and investigate the role of digital and multimedia resources in promoting ecological literacy. By addressing these areas, subsequent studies can further strengthen strategies for developing environmentally responsible and engaged young learners, supporting both local and global sustainability objectives.

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Nargiz Artikova						✓		✓		✓				
Fazilat Khudaikulova					✓					✓				
Bekhzod Xayridinov						✓		✓		✓				
Dildor Otajonova					✓	✓				✓				

C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

CONFLICT OF INTEREST STATEMENT

The author(s) declared no conflict of interest with respect to the research authorship and publication of this article.

DATA AVAILABILITY

Data available within the article or its supplementary materials.

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APPENDIX

Topic: Water is life.

The lesson begins with a brainstorming session:

1	What is water?	4	Do you know Uzbek folk proverbs related to water?
2	What is water for?	5	What fairy tale about water do you know?
3	How do you use water?	6	What poem about water do you know?

Having received answers to these questions, the student will give a conclusion about the sources of water and their quality. In this lesson, students should know the following: don't throw garbage into water; turn off water taps; use water sparingly when washing; how our ancestors used water in the past; the importance of not watering your fields with clean water.

Homework: Observe the current water situation where you live and tell your friends about it in the next lesson.

The teacher explains the course of the experiment in the classroom and at home: the seeds of one of the cultivated plants (for example, cotton, peas, beans) are frozen. To do this, a layer of cotton wool or fabric is spread on the surface of a plate and the seeds are collected on it. The cotton wool or fabric is moistened with water, the seeds are covered with a damp cloth. Students should carefully observe the changes that occur with the seeds during the week, not allowing the cotton wool or fabric to dry out, and record daily in the "Observation Diary" the changes that occur with the seeds that have begun to germinate.

No	What is the moisture content of bean seeds?	What changes occur in the semen?
Monday		
Tuesday		
Wednesday		
Thursday		
Friday		
Saturday		

Within the framework of the experimental curriculum for grades 3–4, the cultivation of environmentally responsible attitudes among primary learners was prioritized. Accordingly, the instructional methodology for delivering content knowledge was scientifically conceptualized, systematically structured, and pedagogically enhanced.

Field trips are a form of organizing educational activities within the classroom environment, serving as an essential tool for fostering ecological education among students. Through the observation of nature, students engage in cognitive processes that enhance their understanding of the interrelationship between biotic and abiotic elements, as well as the ecosystems of flora and fauna. The objective of field trips is to explore the ecological behaviors of trees, plants, insects, and avian species within their habitat.

During the trip, the following methods are used to introduce students to environmental concepts: conversation, story, journey, question and answer, observation, conclusion.

Below is an example of a travel lesson with third-graders.

Topic: What is nature? Us and nature.

The following questions will be answered during the introductory interview with the teacher:

1. What is the importance of the environment in human activity?
2. Why do we honor nature and call it "Mother Nature"?
3. What actions should we take to avoid harming nature?

Students are instructed to refrain from damaging plant branches, disturbing insects, or harming avian species. During excursions, learners document their observations in journals, noting tree species, flora, blossoms, as well as entomological and avian specimens. When completing these tasks, students are recommended to do the following.

№	Types of trees	№	Plants and flowers	№	Insects	№	Birds
1.	Christmas tree	1.	Mint	1.	Cricket	1.	Parrot
2.	Poplar	2.	Tulip	2.	Butterfly	2.	Hook
3.	Apple	3.	Rose	3.	Bee	3.	Canary
4.	Grape	4.	Clover	4.	Ladybug	4.	Pigeon
5.	Pear	5.	Dandelion	5.	Ant	5.	Starling
6.	Dried apricots	6.	Cotton	6.	Spider	6.	Woodpecker

Tree watching

№	Name of the tree	Form	Leaves and colors	Fruits
1.	Mulberry	Large	Yellow. Green.	No fruits
2.				

Observation of plants and flowers

№	Name of plants and flowers	Form	Leaves	Color flowers
1.				
2.				

Insect observation

№	Name of insects	Beneficial insects	Insects – pests	Color - insects
1.				
2.				

Bird watching

№	Name of birds	Place of residence	Their difference	Their similarities
1.				
2.				

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