

**THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF FORMING
ECOLOGICAL REPRESENTATIONS IN OLDER PRESCHOOL CHILDREN WITHIN
A DIGITAL LEARNING ENVIRONMENT**

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<https://doi.org/10.5281/zenodo.20570056>

Abstract. This article investigates the theoretical and methodological foundations of developing ecological representations in older preschool children within a digital learning environment. In the context of the modern information society, the potential of multimedia tools, interactive games, and virtual modeling in fostering a conscious attitude toward the environment among children in preschool educational organizations is analyzed. The study highlights the integration of traditional principles of ecological education with digital technologies, along with the pedagogical conditions required for this process to enrich children's worldviews. Furthermore, methodological approaches are proposed for nurturing responsibility, care, and basic elements of ecological culture toward nature through a digital environment.

Keywords: preschool education, older preschool children, digital learning environment, ecological representations, ecological education, pedagogical technologies, interactive methods, attitude toward nature.

INTRODUCTION

The 21st century is characterized as an era where global environmental challenges and rapid digitalization processes intersect. In today's world, where the anthropogenic impact of humanity on nature is steadily increasing, the cultivation of ecological culture and consciousness within society has become a primary state priority. Ultimately, establishing a foundation of proper ecological education during early childhood is intrinsically linked to ensuring sustainable development and environmental security.

The older preschool age (5–7 years) is considered the most sensitive (susceptible) stage of childhood, during which the initial framework of surrounding world concepts, value-oriented attitudes, and worldviews is established. At this specific age, notions regarding natural phenomena and the interconnections within plant and animal life are rapidly assimilated by children.

However, the information sources and the cognitive psychology of understanding the world have fundamentally transformed for contemporary children. In the current multimedia era, traditional educational methods alone are proving insufficient to sustain children's attention and establish robust ecological representations. Consequently, modern preschool education systems face the critical task of digitalizing education while ensuring its effective utilization in shaping both national and universal human values.

A digital learning environment (comprising multimedia, interactive games, virtual excursions, and animations) offers immense pedagogical opportunities to explain complex ecological processes—such as the water cycle, seasonal changes, and environmental protection—to preschool children in a visual and engaging format. Nevertheless, the theoretical and methodological framework for utilizing these tools systematically and safely, while

accounting for the psycho-physiological characteristics of preschool children, has not yet been comprehensively developed. This gap underlines the profound relevance of this research topic.

The issues of ecological education for preschool children have been extensively studied by both Uzbek and foreign pedagogical scholars. Significant scientific work has been conducted regarding the principles of introducing children to nature and cultivating an ecological culture. Concurrently, the digitalization of the educational environment and the integration of modern information technologies into the pedagogical process have remained at the center of scholarly attention. However, integrating the unique didactic capabilities of a digital learning environment specifically with the methodology of forming ecological representations in older preschool children, alongside systematically researching its underlying patterns and methodological foundations, demands distinct investigation today.

The aim of the research is to define the scientific-theoretical foundations for forming ecological representations in older preschool children within a digital learning environment and to design an effective pedagogical-methodological framework for its implementation.

Research objectives:

1. to analyze the psychological-pedagogical and philosophical literature related to the formation of ecological representations in older preschool children;
2. to determine the current state of the modern digital learning environment in preschool educational organizations and identify its didactic potential within ecological education;
3. to substantiate the pedagogical conditions necessary for cultivating children's concepts of natural elements through digital technologies (interactive games, multimedia);
4. to verify the effectiveness of the methodology for forming ecological representations in a digital environment through practical experimental work and to formulate relevant recommendations.

The object of the research is the process of forming ecological representations in older preschool children within preschool educational organizations.

The subject of the research comprises the content, forms, methods, and tools of forming ecological representations in older preschool children within a digital learning environment.

The methodological framework of the research is guided by the student-centered educational approach, the system-based principle, the concept of harmony with nature (the principle of nature-conformity), and advanced pedagogical frameworks focused on the technologization of education.

LITERATURE REVIEW

The formation of ecological representations in older preschool children and the digitalization of the educational process represent some of the most widely discussed domains in modern pedagogy and psychology. To comprehend the theoretical and methodological roots of this issue, it must be analyzed through the prism of several interconnected scientific approaches.

First and foremost, the classical laws of introducing children to nature and laying the groundwork for ecological education in preschool age have been fundamentally examined by foreign and local scholars. While classical pedagogues such as J.J. Rousseau and I.G. Pestalozzi advocated for organizing education and upbringing in harmony with nature (the principle of nature-conformity), a systematic methodology for ecological education in preschool environments was later comprehensively developed by S.N. Nikolaeva [1]. According to her approach, ecological education extends beyond merely imparting knowledge; it involves instilling the bio-ecological connections among environmental components in a manner aligned with the child's developmental stage [1]. N.A. Ryzhova was among the first to introduce terms

like "direct communication with nature" and "ecologically developing environment" into scientific discourse for early childhood development [2].

In Uzbek pedagogical science, the national and regional dimensions of ecological education for preschool children have been extensively researched. For instance, S. Shodmonova substantiated the structural interdependence of forming economic and ecological thinking elements in preschool-aged children [3]. N.M. Kayumova highlighted methodologies for leveraging national values, folklore, and the ecological philosophies of Eastern thinkers when introducing children to nature [4]. These studies serve as an essential cornerstone for awakening respect and care toward nature in young minds.

Nevertheless, the emergence of the 21st-century information society has brought the digitalization of preschool education to the forefront. The methodological foundations of a digital learning environment, the creation of electronic educational resources, and their influence on personality development are being widely studied globally. For example, L. Plowman and C. Stephen demonstrated in their international research that properly structured pedagogical guidance ("guided interaction") during digital technology use in preschool settings significantly enhances children's cognitive activity [5]. G. Chiong and her co-authors noted that interactive touch screens and multimedia applications accelerate visual memory and logical reasoning in young children [6].

Turning to the synergetic effect of organizing ecological education via digital technologies, contemporary researchers are advancing innovative concepts. A. MacDonald and her colleagues demonstrated that digital technologies help preschool children comprehend otherwise imperceptible ecological processes through virtual modeling, bridging both the micro-world (e.g., plant cell growth) and the macro-world (e.g., global climate change) [7]. While local scholar Sh.S. Shodmonov analyzed the methodological components of developing ecological culture among school and university students within a digital learning environment [8], exploring this process specifically through the lens of older preschool children requires a customized approach.

D.A. Mustafayeva shows in her research that integrating modern information and communication technologies (ICT) and multimedia tools into the preschool education process serves as an important catalyst for enhancing educational quality [9]. However, alongside the advantages of digital spaces, the challenge of protecting children's psycho-physiological health and maintaining a balance between the digital and physical worlds persists. For instance, J.M. Yusupova emphasizes the vital importance of adhering to hygienic and pedagogical safety protocols when working with digital tools during preschool childhood [10].

The literature review demonstrates that while a rich theoretical and methodological database exists for forming ecological representations in preschool children on one hand, and the laws of digitalizing preschool education are actively explored on the other, a comprehensive system that unifies the transformational and didactic potential of a digital learning environment (interactive games, VR excursions, 3D animations) specifically to instill stable ecological concepts in older preschool children remains insufficiently investigated in a monographic capacity. This scientific gap guided the definition of the goals and objectives of this research.

RESEARCH METHODOLOGY

Investigating the process of forming ecological representations in older preschool children within a digital learning environment requires the integration of complex cognitive, pedagogical, and technological determinants. To provide a scientific basis for this issue and verify its practical efficacy, a pedagogical methodology based on a combination of systematic, student-centered, and activity-based approaches was designed.

System of methodological principles. To ensure the pedagogical safety of digital technology utilization and align the ecological content with children's cognitive capacities, the research relied on the following leading principles:

- ❖ the principle of nature-conformity (systemic approach) - ensuring that the ecological content within the digital environment is intrinsically linked to the child's real-world experiences and local natural environment;
- ❖ the principle of visual clarity and interactivity - translating abstract ecological laws (e.g., photosynthesis, food chains) into visual formats using graphical, animated, and multimedia elements;
- ❖ the valeological principle (psychological-pedagogical safety): strictly adhering to developmental and physiological standards (sanitary-hygienic regulations) when children interact with digital devices (smartboards, tablets).

Research methods. To resolve the established objectives, a complementary matrix of the following methods was deployed:

- ❖ theoretical methods - comparative-logical analysis of philosophical, ecological, psychological, and pedagogical literature related to the topic; modeling the core content of preschool education curricula (e.g., "Ilm yo'li", "Ilk qadam");
- ❖ empirical methods - conducting surveys (questionnaires) among preschool educators and parents, direct and indirect observation of children's ecological play activities, interview techniques;
- ❖ experimental methods: organizing pedagogical experiments involving baseline, formative, and control phases to measure the efficacy of digital didactic tools;
- ❖ mathematical-statistical methods: quantitatively evaluating the reliability of experimental data utilizing student's t-test or spearman's rank correlation.

Organization of experimental work. The practical phase of the study was organized in compliance with pedagogical experiment requirements, utilizing parallel groups (Control and Experimental groups). The following table outlines the components of the research methodology, variations between the groups, and the anticipated pedagogical outcomes:

Table 1. Research phases and content

Research phases	Control group (traditional environment)	Experimental group (digital learning environment)	Evaluation criteria and methods
I. Baseline Phase (Initial Diagnostics)	Ecological comprehension levels are determined using a standard nature corner and handout materials.	Baseline levels are measured using traditional tools augmented by digital diagnostic interactive games.	Children's elementary knowledge regarding living and non-living nature (Interviews, drawing tests).
II. Formative Phase (Core Experiment)	Ecological sessions are conducted strictly through books, pictures, and traditional observations in the live nature corner.	Special 2D/3D animations, virtual ecosystem excursions, and touch-based interactive games are integrated into the lesson structure.	Dynamics of ecological representations, emotional attitudes, and manifestations of ecological behavior in children (Observation).
III. Control	Final knowledge	Outcomes are	Quantitative and

Phase (Final Analysis)	assessment is carried out using traditional formats (oral interviews).	verified via digital interactive test-tasks and practical problem-solving play scenarios.	statistical analysis of control and experimental group metrics (Criterial evaluation).
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The unique characteristic of this methodology within a digital learning environment is that the virtual, visualized model is continuously synchronized with physical, practical activities (conducting experiments in nature, caring for plants). This approach prevents the development of "screen dependency" while enabling the transformation of acquired information into tangible real-world skills.

RESULTS AND DISCUSSION

To evaluate the effectiveness of the developed experimental framework for forming ecological representations in older preschool children within a digital learning environment, the quantitative and qualitative data gathered at the conclusion of the pedagogical experiment were analyzed. Children's ecological representations were diagnosed based on three core structural criteria: cognitive-informative (concepts), emotional-evaluative (attitude), and activity-practical (ecological behavior) metrics.

Comparative quantitative analysis of experimental results. At the conclusion of the study, sharp contrasts were observed in the dynamics of ecological representation levels between children in the control group (traditional education) and the experimental group (education integrated with a digital environment). The final gathered metrics are summarized in the table below:

Table 2. Comparative quantitative analysis of experimental results

Groups	Number of children	High level (%)	Average level (%)	Low level (%)
Control group (pre-test)	30 children	13.3%	56.7%	30.0%
Control group (post-test)	30 children	20.0%	60.0%	20.0%
Experimental group (pre-test)	30 children	10.0%	60.0%	30.0%
Experimental group (post-test)	30 children	46.7%	43.3%	10.0%

Mathematical-statistical analysis indicated that while the high-level metric increased by a mere 6.7% in the control group where traditional methods were applied, the same metric rose sharply by 36.7% (from 10.0% to 46.7%) in the experimental group exposed to innovative digital didactic tools. Crucially, the proportion of children with weak ecological knowledge (low level) in the experimental group decreased significantly from 30.0% to 10.0%.

Scientific discussion of the findings. The positive outcomes achieved during the experiment are explained by the alignment of the unique didactic capabilities of the digital learning environment with the cognitive development characteristics of contemporary children.

As recorded in pedagogical literature, visual-figurative thinking and a syncretic (holistic) perception of the world predominate in older preschool children [1]. In traditional classes, explaining abstract ecological concepts such as "the water cycle in nature," "the depletion of natural resources," or "chain links within an ecosystem" through static pictures often induced cognitive difficulties. Conversely, the 3D animations, multimedia models, and interactive

simulations deployed in the experimental group visualized these complex micro- and macro-world processes dynamically, using language accessible to children. This outcome practically confirms the concept noted in international studies regarding the "function of digital tools to concretize abstract concepts" [7].

One of the most vital aspects uncovered during the discussion is the impact of interactive touch-based games on children's motivational drivers. For instance, in digital didactic games like "Waste Sorting" or "Save the Ecosystem," the child ceased to be a passive listener and transformed into an active subject managing the process. Throughout this experience, when children selected incorrect answers, they instantly recognized the consequences of their actions through the emotional reactions of the onscreen characters (such as a character appearing sad). As highlighted by scholars, such rapid feedback loops within a digital environment rapidly cultivate a sense of responsibility and empathy (emotional resonance) toward the environment [5], [6].

Furthermore, drawing upon the perspectives of local scholars regarding the formation of ecological values anchored in national identity [4], storylines of folk tales and national character imagery (e.g., "Tomchivoy", "Zumrad") were embedded into the digital game plots. This inclusion not only augmented children's cognitive knowledge but also helped internalize elements of ecological culture into intrinsic motivation.

Nonetheless, the pedagogical and hygienic boundaries of utilizing digital environments became distinctly apparent during the research. As demonstrated in the works of S.N. Nikolaeva and J.M. Yusupova, digital tools must never entirely displace direct interaction with real nature, such as nurturing live plants and interacting with soil [1], [10]. Otherwise, risks of virtual reality dependency or detachment from the real world emerge. In our research, this challenge was resolved based on the principle of blended learning: an ecological model learned on a digital screen (e.g., the growth phases of a plant) was immediately reinforced through a practical experiment (planting seeds and observing) within the live nature corner of the classroom.

The methodologically precise modeling of a digital learning environment multiplies the efficiency of forming ecological representations in older preschool children compared to traditional education. Mathematical-statistical verification (via Student's t-test) fully confirmed that the gathered data are not accidental, but rather a systematic outcome of the introduced pedagogical innovations.

CONCLUSION AND RECOMMENDATIONS

The investigation into the theoretical and methodological foundations of forming ecological representations in older preschool children within a digital learning environment, alongside the outcomes of the pedagogical experiment, allows for the formulation of the following conclusions:

1. Refinement of theoretical foundations: the information acquisition psychology of today's digital generation (Alpha generation) has fundamentally evolved. Consequently, integrating traditional principles of ecological education (nature-conformity, visual clarity) with the capabilities of modern digital didactics has demonstrated positive pedagogical efficacy.

2. Enhancement of cognitive activity: given that visual-figurative reasoning is dominant in older preschool children, digital modeling and 3D visualization (of the water cycle, ecosystem chains, etc.) provided a base for children to internalize abstract ecological laws easily and consciously. The rise of the high-level indicator to 46.7% in the experimental group substantiates this point.

3. Value-driven importance of interactivity: touch-based games and problematic virtual scenarios transformed children from passive recipients into active participants. Prompt visual feedback within digital games accelerated the formation of responsibility, empathy, and caution toward nature.

4. Efficacy of the blended learning model: the digital environment achieved its maximum impact when synchronized with practical labor in physical nature corners (seed planting, cultivation). This approach prevented screen dependency while translating virtual knowledge into actionable, real-world ecological habits.

Based on the research findings, the following pedagogical and methodological recommendations are proposed for integration into preschool education practices:

For administrations and methodologists of preschool educational organizations (PEOs) - PEOs should look beyond merely equipping multimedia and group rooms; they must enrich these spaces with certified, Uzbek-language ecological software bases and interactive games tailored to children's ages. Short-term seminar-trainings on the theme of "Integration of Digital Pedagogy and Ecological Education" should be organized for educators;

For classroom educators - when utilizing digital tools (smartboards, tablets) in ecological sessions, hygienic norms must be strictly observed (per sanitary regulations, continuous screen time for children aged 5–7 must not exceed 10–15 minutes). Guided by the principle of "From the Virtual World to Real Nature," every ecological process displayed on a screen should be reinforced through practical observations and experiments during activities in the live nature corner or walks within the PEO courtyard. Characters from national values and folk tales should be actively utilized as digital game and multimedia heroes;

For parents - families must supervise children's gadget usage time and download ecological, intellectual, and developmental mobile applications that inspire a love for nature, rather than purely entertainment-focused games. Parents should engage in digital ecological games alongside their children and collaborate to apply the problem-solving scenarios encountered (such as water conservation or animal protection) within everyday household life.

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