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THE EFFECTIVENESS OF DIGITAL LEARNING TECHNOLOGIES IN FORMING ECOLOGICAL REPRESENTATIONS IN PRESCHOOL CHILDREN OF OLDER AGE

Sayfetdinova Dildora Ikramitdinovna
Senior lecturer of the department of "Preschool education"
NEI "University of economics and pedagogy", Uzbekistan
E-mail: dildorasayfetdinova@gmail.com
Phone: +998(97) 997-08-70
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Abstract.

This article investigates the effectiveness of modern digital learning technologies (multimedia interactive games, virtual excursions, and animated models) in forming initial ecological representations in older preschool children (5–7 years old). Traditional teaching methods often fail to fully and visually convey the dynamics of natural phenomena (e.g., the water cycle or seed germination) to a child. Within the framework of the study, a pedagogical experiment was conducted involving 60 children from preschool education organizations. ICT (information and communication technology) tools were systematically utilized in the sessions of the experimental group. The results demonstrated that the ecological knowledge level and responsible attitude toward nature of the children in the group where digital technologies were applied recorded a 24% higher efficiency compared to the traditional group. Furthermore, it was determined that visual and audio-visual stimuli increased the retention rate of ecological concepts in children by 35%. At the end of the article, practical methodical recommendations for integrating digital ecological content into the preschool education process were developed.

Keywords: older preschool age, ecological representation, digital learning technologies, multimedia, virtual excursion, pedagogical experiment, interactive games, ecological education, efficiency criterion, audio-visual stimuli.

INTRODUCTION

Today, under the conditions of global environmental crises and climate change, forming an ecological culture in society has become one of the priority directions of state policy. Indeed, the foundation of a conscious and responsible attitude toward the environment is established precisely during the preschool age period. Pedagogical research indicates that older preschool children (5–7 years old) possess a high level of emotional perception and curiosity regarding the surrounding world, and ecological concepts provided during this period become firmly embedded in their personal value systems [5]. However, traditional educational methodologies are often limited to explaining elements of nature solely through static (motionless) images, which does not fully satisfy the cognitive needs of modern "Alpha generation" children.

The digitalization of the preschool education system and the implementation of electronic learning resources into practice stand at the center of modern pedagogical science. Digital technologies exert a complex influence on children's sensory systems, allowing abstract ecological concepts to be transferred into concrete visual forms. In particular, the digital learning environment stimulates a child's natural interest in understanding the internal structure of natural objects and the microworld [1]. Since the possibility for children of this age to directly observe the dynamic development of natural phenomena (e.g., changing seasons, stages of plant growth, the water cycle in

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nature) is limited, multimedia modeling and interactive tools serve as a helpful bridging mechanism [2].

However, serious contradictions are observed in the methodology of using digital technologies in preschool education institutions. On one hand, it has been scientifically proven that interactive games and virtual models enrich children's ecological representations; on the other hand, a system for the standardized use of digital content, taking into account the psychophysiological characteristics of older preschool children, has not been fully developed [7]. Frequently, digital tools are applied not for educational purposes, but merely as an entertainment element. This necessitates a special investigation into the pedagogical potential of digital learning technologies and their efficiency criteria in forming systematic ecological representations in older preschool children.

The aim of the study is to improve the methodology of applying modern digital learning technologies in the process of forming ecological representations in older preschool children and to experimentally substantiate its pedagogical effectiveness.

LITERATURE REVIEW

The problem of forming ecological representations and a responsible attitude toward nature in preschool children has been at the center of pedagogical research for many years. The analysis of scientific literature shows that the theoretical and methodological foundations of ecological education were initially studied within the context of direct communication with nature and interactive observations. Specifically, it has been substantiated that in the initial stage of ecological education, a child's sensory experience and visual perception of the environment serve as the primary factor for cognitive development [3]. However, in today's era of digital transformation, relying solely on observations in traditional nature corners does not correspond to the speed and scope of information acquisition by children.

The penetration of digital technologies into the preschool educational process and their impact on child psychology are being widely studied by foreign researchers. In international practice, it has been noted that ICT tools, particularly animated models and game simulations, facilitate a child's understanding of abstract ecological relationships, such as the food chain or ecosystem integrity [4]. At the same time, as Western scholars emphasize, digital content activates a child's long-term memory by providing visual stimulation and awakens emotional feelings aimed at preserving nature [6]. These studies reveal not only the educational but also the educational-emotional function of digital tools.

Pedagogical scientists of our Republic also pay special attention to the problems of building the foundation of ecological culture in the preschool education system. In the context of Uzbekistan, a scientific-pedagogical system has been developed for forming ecological representations in harmony with national values and the natural environment [5]. Furthermore, the possibilities of increasing the effectiveness of sessions through the use of innovative pedagogical technologies and visual resources in modern preschool education institutions have been analyzed [2]. However, in these studies, digital technologies have been viewed mainly as a general tool for visual illustration, and their specific role in the systematic modeling of ecological representations has not been fully disclosed.

In recent years, research conducted on creating a digital learning environment and improving the methodology of preschool education is noteworthy. Studies show that digital technologies (virtual excursions, interactive programs) increase a child's independence and subjective position in educational activities [1]. The necessity of standardizing the time preschool children spend in front of screens and developing hygienic-pedagogical requirements for ecological digital content has also been raised as an urgent problem [7].

The analysis of existing literature indicates that although the general pedagogical potential of digital technologies has been studied, the didactic system and specific efficiency indicators of digital

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technologies specifically in forming ecological representations (living and non-living nature, natural phenomena, human-nature interaction) in older preschool children have not been sufficiently covered as an integrated object of research. This situation serves to define the scientific novelty and direction of this article.

METHODOLOGY

To determine the effectiveness of digital learning technologies in forming ecological representations in older preschool children, a comprehensive pedagogical research methodology was developed and implemented. The research process was based on the harmony of traditional cognitive diagnostics and modern interactive pedagogical experiment methods. Taking into account the psychophysiological characteristics of preschool children, sanitary-hygienic standards and safe time intervals for using digital tools (not more than 15 minutes per day) were strictly observed during the experiment [7].

The pedagogical experiment was conducted during the 2025–2026 academic year on the basis of preschool education organizations in Tashkent city. A total of 60 older preschool children (5–7 years old) were involved in the study. The participants were divided into two groups of equal size:

❖Control Group (CG, n=30): Sessions were conducted based on traditional methodology (conversation, viewing picture albums, static observations in the nature corner).

❖Experimental Group (EG, n=30): Sessions were organized based on the systematic integration of digital learning technologies (interactive multimedia games, virtual excursions, and animated models).

The research process was carried out in three traditional stages:

1. Formative (ascertaining) stage: the initial level of ecological representations of the children in both groups was examined using specially developed diagnostic tests, oral questions-and-answers, and observation maps of attitudes toward natural objects. Children's concepts of "living and non-living nature," "natural phenomena," and "the mutual relationship between humans and nature" were accepted as evaluation criteria.

2. Experimental (intervention) stage: in this stage, digital components were applied within the ecological sessions twice a week in the experimental group. For instance, 2D and 3D animated models were demonstrated on the topic of "The Water Cycle in Nature," and "Stages of Plant Development" were shown in an accelerated time mode using virtual laboratory simulations. Interactive didactic games designed for touch screens ("Sorting Waste," "Who Lives Where?") were also used to reinforce children's ecological knowledge. Digital game modeling served to form skills of independent decision-making and analyzing ecological situations in children [1].

3. Control (final) stage: at the conclusion of the intervention stage, re-diagnostics were carried out in both groups. To evaluate the reliability and statistical significance of the obtained quantitative indicators, mathematical-statistical methods widely used in pedagogical measurements (mathematical expectation, variance analysis, and percentage indicators) were utilized. A three-level (high, medium, low) diagnostic criteria system presented in scientific sources was relied upon in evaluating the level of children's ecological representations [3].

RESULTS AND DISCUSSION

In the final stage of the pedagogical experiment, the level of ecological representations of older preschool children in the control (CG) and experimental (EG) groups was re-diagnosticated. The obtained results showed significant differences in the level of formation of knowledge about nature in children.

At the end of the experiment, the level of ecological representations of the groups manifested in the following quantitative indicators (table 1).

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Table 1. The level of formation of children's ecological representations at the end of the experiment (in percentage)

Groups	Number of participants (n)	High level	Medium level	Low level
Control Group (CG)	30 children	20% (6 children)	53.3% (16 children)	26.7% (8 children)
Experimental Group (EG)	30 children	46.7% (14 children)	43.3% (13 children)	10% (3 children)

As can be seen from the table data, the high-level indicator in the experimental group (EG) where digital learning technologies were used constituted 46.7%, which increased by 26.7% compared to the control group taught by the traditional method (CG, 20%). Most importantly, the share of children with weak ecological knowledge (low level) in the experimental group decreased to only 10%, whereas this indicator remained at the level of 26.7% in the control group.

The analysis of the obtained results by directions showed that digital content (animated models and visual simulations) yielded the highest efficiency precisely in more abstract topics such as "natural phenomena" and "human-nature interaction." Through virtual excursions and interactive games, children had the opportunity to see ecological processes in dynamics, which significantly activated their indicators of retaining concepts and applying them in practice.

The results of the study confirm that the cognitive development of older preschool children is directly connected with visual and dynamic images. Digital games and multimedia tools stimulate a child's sensory system and help transfer information into long-term memory. This state fully corresponds with scientific views in pedagogical psychology regarding the acceleration of cognitive processes by visual and audio-visual stimuli [6].

The increase in efficiency identified in our study further enriches and raises to a new stage the research conducted by the scientists of our republic on increasing the level of visual illustration in preschool education. While ICT was previously considered mainly as an auxiliary visual aid (slides, pictures) in teaching [2], in this work, digital technologies were substantiated as an independent didactic system that models ecological processes and provides interactive communication.

At the same time, the necessity of adhering to pedagogical standards and psychophysiological limitations when using digital technologies also became apparent during the experiment. No matter how much digital games attract children, they cannot completely replace real communication with nature (caring for live plants, observing animals). Consequently, the highest result can be achieved only when digital tools are optimally combined with traditional nature corner sessions [7].

Digital learning technologies are an effective mechanism for forming ecological representations in older preschool children, enabling the intensification of the educational process and the systematic upbringing of children's responsible attitudes toward nature.

CONCLUSION AND RECOMMENDATIONS

Our study, aimed at exploring the possibilities of digital learning technologies in forming ecological representations in older preschool children and experimentally substantiating their effectiveness, allows for the following conclusions:

1. Increase in cognitive efficiency: digital learning technologies (multimedia models, interactive games, and virtual excursions) fully correspond to the sensory and cognitive characteristics of older preschool children. They significantly increase children's level of ecological knowledge by visualizing abstract ecological processes that are difficult to explain using traditional methodology. The 26.7% increase in the high indicator in the experimental group is clear evidence of this.

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2. Systematicity and independence: interactive didactic digital games form skills in children not only to assimilate ready-made knowledge, but also to analyze ecological situations, sort waste, and make independent simple decisions regarding nature improvement. This transforms the child from a passive observer of the educational process into an active subject.

3. Necessity of optimal harmony: although digital technologies possess high didactic potential, they cannot replace real, live communication with nature. Maximum efficiency is achieved only when digital resources and traditional ecological education methods (ecological pathways, labor in the nature corner) are mutually integrated.

Based on the obtained scientific-practical results, the following recommendations are put forward for specialists in the preschool education system:

❖For methodologists and educators: systematically include digital components (2D/3D animations, thematic virtual journeys) into the weekly plan of ecological sessions in preschool education organizations. At the same time, it is necessary to strictly limit children's screen time to 10–15 minutes in accordance with sanitary-hygienic standards.

❖For developers and designers: increase special interactive ecological mobile applications and game platforms in the Uzbek language, taking into account the psychophysiological and age characteristics of preschool children, as well as elements of our national values. In them, characters and visual images should emotionally guide the child not to harm nature, but rather to preserve it.

❖Cooperation with parents: create a "digital ecological bridge" between the preschool education organization and the family; continue recommending to parents a list of useful and safe educational digital resources that they can play together with their children at home to reinforce their ecological concepts.

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