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### **DEVELOPING NATURAL-SCIENCE LITERACY THROUGH FORMING ECOLOGICAL CONCEPTS AMONG PRIMARY SCHOOL STUDENTS**

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#### **Abstract**

The article examines, from a socio-pedagogical perspective, the role of forming ecological concepts among primary school students in developing natural-science literacy. The author substantiates the step-by-step mechanism of ecological concept formation, the core components of natural-science literacy, and the pedagogical conditions and methods that foster their development, and puts forward practical recommendations.

**Keywords:** Ecological concept, natural-science literacy, primary education, observation skills, research competence, functional literacy, PISA, pedagogical conditions.

#### **Introduction**

Developing students' functional literacy, and natural-science literacy in particular, is becoming one of the pressing pedagogical tasks in the modern education system. The international PISA assessment programme interprets natural-science literacy as a person's ability to explain natural phenomena scientifically, to design



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investigations, and to apply scientific evidence in real-life situations <sup>1</sup>. The foundation of this ability is laid precisely at the primary-education stage, during the period when a student's first ecological concepts are being formed.

Primary-school age is a sensitive period in which the child actively perceives the environment and shows strong interest in natural phenomena. The ecological concepts formed during precisely this period - initial representations of categories such as nature, ecosystem, natural resources, and ecological balance - later serve as the cognitive foundation for the student's conscious mastery of the natural sciences and for reasoning grounded in scientific evidence. It is therefore appropriate to regard the process of forming ecological concepts as an integral part of developing natural-science literacy. In other words, ecological concepts serve as the "primary building block" from which a person's entire system of knowledge about nature and society is constructed, which is why the quality of their formation determines the effectiveness of natural-science education at every subsequent stage.

In recent years, reforms aimed at developing students' functional literacy up to international standards have been carried out within the general secondary education system, and the content of natural-science curricula and textbooks has likewise been updated from this standpoint. Changes at the level of curricula and textbooks do not, however, produce results by themselves - they yield an effect only when they are matched by day-to-day pedagogical practice in the classroom, in particular by the methods through which the teacher conveys ecological concepts.

At the same time, in practice ecological education is often observed to be conducted separately, disconnected from the task of developing natural-science

<sup>1</sup>Jordan R.C., Singer F., Vaughan J., Berkowitz A.R. What should every citizen know about ecology? // Frontiers in Ecology and the Environment, 2009, 7(9), P.495-500.



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literacy: students memorise ecological terms but are unable to connect them with research skills such as observation, comparison, and drawing conclusions. The purpose of this article is therefore to analyse the process of forming ecological concepts among primary school students in close connection with the development of natural-science literacy, and to substantiate the pedagogical conditions and methods that ensure this process.

### Literature Review and Methodology

Ecological concepts and natural-science literacy have been addressed in a number of studies. R. Jordan and co-authors developed a theoretical framework defining what every citizen should know about ecology, interpreting ecological literacy as a continuous process that begins to form as early as primary school and continues throughout a person's life <sup>2</sup>. An experimental study conducted by M-C. Ricoy and C. Sánchez-Martínez demonstrates that gamification technologies serve to raise both ecological awareness and digital literacy in primary school students simultaneously <sup>3</sup>. Among local studies, G.Sh. Choriyeva systematises the factors and pedagogical conditions that shape natural-science literacy <sup>4</sup>, while N.T. Misirova and co-authors reveal the content and methods of introducing primary school students to nature <sup>5</sup>. D.A. Suyunov, in two of his works, analyses the means of forming ecological thinking in students and the issue of creating a positive

<sup>2</sup>Jordan R.C., Singer F., Vaughan J., Berkowitz A.R. What should every citizen know about ecology? // *Frontiers in Ecology and the Environment*, 2009, 7(9), P.495-500.

<sup>3</sup>Ricoy M-C., Sánchez-Martínez C. Raising Ecological Awareness and Digital Literacy in Primary School Children through Gamification // *International Journal of Environmental Research and Public Health*, 2022, 19(3), 1149.

<sup>4</sup>Choriyeva G.Sh. Tabiiy-ilmiy savodxonlikni shakllantirish omillari va pedagogik shart-sharoitlar // «Maktabgacha va maktab ta'limi» jurnali, 2025, 3(11). – B.7-11.

<sup>5</sup>Misirova N.T., Xursanova M., Ummatqulova A. Boshlang'ich sinf o'quvchilarida tabiiy-ilmiy savodxonlikni rivojlantirish mazmuni // «Maktabgacha va maktab ta'limi» jurnali, 2026, 4(2). – B.15-19.



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attitude towards nature among teachers <sup>67</sup>. S.M. Mustafayev and O‘.A. Axmedov, for their part, set out the modern concept of natural knowledge and define the theoretical foundations of natural-science education <sup>8</sup>. At the same time, there is still a shortage of studies that model the stage-by-stage formation of ecological concepts in direct connection with the specific components of natural-science literacy - a gap that underlines the relevance of this article's topic. The study employed theoretical analysis, pedagogical observation, comparative analysis, and generalisation.

### Analysis and Results

The formation of ecological concepts in a primary school student is not instantaneous but a complex cognitive process that unfolds step by step. In the first, sensory-perceptual stage, the student takes in natural objects (plants, animals, water, soil) through direct observation and distinguishes their external features. In the second, representational stage, simple connections between these objects (for example, "sun - warmth - plant growth") begin to take shape in the student's mind as an integrated image. In the third, conceptual-logical stage, the student moves from separate facts to a generalised conclusion, reaching a level at which concepts such as "ecosystem," "natural balance," and "rational use of resources" can be independently explained and applied to new situations. As D.A. Suyunov notes, the consistent provision of these stages ensures the formation not

<sup>6</sup>Suyunov D.A. Boshlang‘ich sinf o‘quvchilarida ekologik tafakkurni shakllantirish vositalari // Science and innovation. International scientific journal, 2022, (5-P). – B.43-47.

<sup>7</sup>Suyunov D.A. Boshlang‘ich sinf o‘qituvchilarida tabiiy fanlarni o‘qitishda tabiatga nisbatan ijobiy muhitni shakllantirish // Inter education & global study, 2024, (8). – B.349-354.

<sup>8</sup>Mustafayev S.M., Axmedov O‘.A. Tabiiy bilimlar zamonaviy konsepsiyasi. – T.: Aloqachi, 2010. – 224 b.



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only of ecological knowledge in the student but also of a conscious attitude toward nature and independent thinking skills <sup>9</sup>.

In implementing these stages, it is important to take into account the age characteristics of students. In grades 1–2, ecological concepts form mainly at the sensory-perceptual and representational stages: students learn by seeing, touching, and smelling natural objects, so observation and elements of play should predominate at this stage. In grades 3–4, thinking begins to take on an analytical character, so it is advisable to offer tasks that involve identifying cause-and-effect relationships, performing simple comparison and classification exercises, and recording observation results in the form of tables or diagrams.

Natural-science literacy comprises three interrelated components: the ability to explain natural phenomena scientifically (the knowledge component), the skill of observation and conducting simple research (the activity component), and a value-based attitude toward nature and toward decisions grounded in scientific evidence (the attitude component) <sup>10</sup>. Forming ecological concepts in primary school makes it possible to develop all three of these components at once: as the student masters an ecological concept, they observe the related phenomenon, draw a conclusion from it, and form their own attitude toward it. In this way, ecological concepts function as the "primary cell" of natural-science literacy.

Experience of participating in international studies assessing the quality of education shows that, although a large proportion of Uzbekistani students perform well on natural-science tasks that require holding theoretical information in memory, they encounter difficulty with tasks that require independently analysing a phenomenon and drawing conclusions from observational data. This

<sup>9</sup>Suyunov D.A. Boshlang'ich sinf o'quvchilarida ekologik tafakkurni shakllantirish vositalari // Science and innovation. International scientific journal, 2022, (5-P). – B.43-47.

<sup>10</sup>Jordan R.C., Singer F., Vaughan J., Berkowitz A.R. What should every citizen know about ecology? // Frontiers in Ecology and the Environment, 2009, 7(9), P.495-500.



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once again confirms the need to form ecological concepts, from the very stage of primary education, not merely through memorisation but through observation and reasoning.

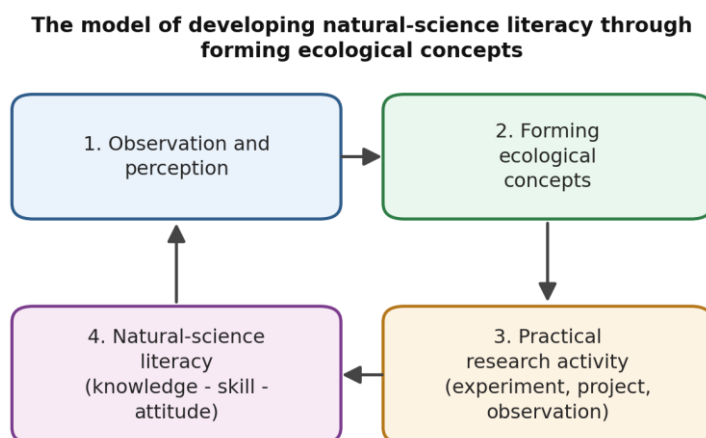


**Figure 1. The model of developing natural-science literacy through forming ecological concepts**

As the diagram shows (Figure 1), the process, beginning with observational activity, develops all three components of natural-science literacy through the formation of ecological concepts; this, in turn, further enriches the student's practical research activity, and the process repeats cyclically.

The effectiveness of forming ecological concepts depends largely on the pedagogical conditions and methods employed. First, direct observation and excursions - regular observations conducted in a garden, a yard, or a nearby corner of nature - form in the student a reliable representation of natural phenomena grounded in personal experience. Second, simple experiments and research tasks (such as the evaporation of water, the germination of a seed, or comparing soil composition) turn the student from a passive listener into an active



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researcher, which, in Choriyeva's view, is the most effective expression of problem-based and activity-based learning <sup>11</sup>. Third, project work - small projects such as "My Ecological Notebook" or "Our Class Garden" - gives students the opportunity to apply their knowledge in practice. Fourth, game-based technologies and digital tools (didactic games, ecological quizzes, presentations) increase student motivation and, as M-C. Ricoy and C. Sánchez-Martínez have shown, develop digital literacy alongside ecological awareness <sup>12</sup>.

The topics of the primary-education "Natural Sciences" curriculum offer rich opportunities for connecting ecological concepts with the components of natural-science literacy. For example, the topic of "the water cycle," studied through observation and a simple experiment (heating water and observing its evaporation), forms in the student the ability to explain a phenomenon scientifically; the topic of "the changing of the seasons," studied by keeping a seasonal observation notebook, develops the skill of recording and comparing changes; and the topic of "plant life," through a small experiment conducted in the classroom or a garden plot (planting a seed and observing its growth), gives students experience in formulating and testing a hypothesis. Such a linkage of topic, method, and component turns an ecological concept from a dry term into an instrument of practical research activity.

In practice, the consistent application of these conditions is achieved through a number of concrete methods. Seasonal nature observations, recorded in a notebook through drawings and brief notes, form in the student concepts of time and change. Conversations organised around the "why?" technique encourage the

<sup>11</sup>Choriyeva G.Sh. Tabiiy-ilmiy savodxonlikni shakllantirish omillari va pedagogik shart-sharoitlar // «Maktabgacha va maktab ta'limi» jurnali, 2025, 3(11). – B.7-11.

<sup>12</sup>Ricoy M-C., Sánchez-Martínez C. Raising Ecological Awareness and Digital Literacy in Primary School Children through Gamification // International Journal of Environmental Research and Public Health, 2022, 19(3), 1149.



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student to independently seek the cause of an observed phenomenon. Small extracurricular ecological activities - planting seedlings, game-based exercises in sorting waste - turn knowledge into skill. As N.T. Misirova and co-authors note, such an integrated approach serves to turn the student not merely into a possessor of knowledge but into an active researcher <sup>13</sup>.

Forming ecological concepts proceeds more effectively not within a single subject but on the basis of interdisciplinary integration. Working with nature-themed texts in native-language lessons enriches the student's ecological vocabulary, while representing observation results (for example, daily temperature changes) in tables and diagrams in mathematics lessons develops the skill of scientifically interpreting numerical data. Drawing nature-themed pictures and making objects from natural materials in visual-art and handicraft lessons strengthens the student's aesthetic and emotional attitude toward nature. Such an interdisciplinary approach makes it possible to form the ecological concept as a holistic, multifaceted body of knowledge.

Effectively managing the process of forming ecological concepts requires the use of suitable assessment tools. Traditional written tests or quizzes mostly measure the knowledge component but do not fully capture the activity and attitude components. It is therefore recommended to use alternative assessment tools such as observation journals, portfolios of small research projects, and observation sheets for tracking the process of completing a practical task. Such tools enable the teacher to assess not only the student's theoretical knowledge but also the level of their research skills, such as observation, comparison, and drawing conclusions.

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<sup>13</sup>Misirova N.T., Xursanova M., Ummatqulova A. Boshlang'ich sinf o'quvchilarida tabiiy-ilmiy savodxonlikni rivojlantirish mazmuni // «Maktabgacha va maktab ta'limi» jurnali, 2026, 4(2). – B.15-19.



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The effectiveness of forming ecological concepts also depends on cooperation between the family and the school. Simple ecological practices organised at home - caring for houseplants, sorting waste, using water and electricity economically - make it possible to transfer the concepts being formed at school into everyday life. To this end, teachers can suggest simple "home tasks" for families, such as tracking a household's water consumption for a week or sorting household waste by type, which helps the student test the knowledge gained at school in a real-life situation.

It should be particularly emphasised that the effectiveness of this process depends directly on the teacher's professional preparation. As S.M. Mustafayev and O'.A. Axmedov note, a teacher who has not fully mastered the modern concept of natural knowledge conveys ecological concepts only at the level of rhetoric and is unable to connect them with practical research activity <sup>14</sup>. For this reason, the in-service training system for teachers needs to strengthen the ecological-pedagogical component, including the methodology for organising simple natural-science experiments.

It is also worth noting that, in the process of forming ecological concepts, the quality of methodological guides and didactic materials is of particular importance. Most existing textbooks and manuals are based on general, nationwide natural examples, while practical tasks linked to the natural features of the local area - for example, the plant and animal life specific to a particular region, or seasonal climatic features - are rare. Developing observation and experiment tasks adapted to the local natural environment helps ecological concepts form in the student not merely as abstract knowledge but as knowledge that is personally meaningful and connected to the area in which they live.

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<sup>14</sup>Mustafayev S.M., Axmedov O'.A. Tabiiy bilimlar zamonaviy konsepsiyasi. – T.: Aloqachi, 2010. – 224 b.



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On the basis of the above analysis, a number of practical recommendations can be summarised for primary-school teachers: reinforce every natural-science topic with at least one observation or simple experiment; encourage students to reach conclusions through independent observation rather than being given a ready-made conclusion; keep an observation notebook in the classroom on a regular basis; make use of examples drawn from the local natural environment; and take the process of practical activity into account in assessment, not only written knowledge.

Analysis of practice shows that a number of problems persist in organising ecological education in primary grades: in many cases, instruction is theoretical and terminological in character, with practical research activity occupying insufficient space; the criteria used to assess students are oriented more toward measuring memorised knowledge and less toward measuring scientific-thinking skills; and textbooks and methodological guides lack sufficient practical tasks adapted to the features of the local natural environment. Overcoming these problems would make it possible to turn the process of forming ecological concepts into a fully legitimate means of developing natural-science literacy.

### **Conclusion**

The analysis carried out makes it possible to draw the following conclusions. First, ecological concepts in primary school students form consistently through the sensory-perceptual, representational, and conceptual-logical stages, and this process proceeds effectively when methods appropriate to the student's age characteristics are chosen. Second, forming ecological concepts makes it possible to develop the knowledge, activity, and attitude components of natural-science literacy simultaneously, which is why it is advisable to form them not in isolation from one another but as an integrated system. Third, direct observation, simple



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experiments and research tasks, project work, game-based technologies, and interdisciplinary integration prove to be the most effective pedagogical means of forming ecological concepts. Fourth, cooperation between family and school, together with the use of alternative assessment tools (observation journals, project portfolios), are important factors that increase the effectiveness of the process. At the same time, problems persist in practice, such as ecological education remaining theoretical and terminological in character, a shortage of practical research activity, and assessment criteria not fully corresponding to the requirements of natural-science literacy. In this connection, it is advisable to incorporate ecology-oriented practical research tasks more broadly into the content of primary education, to strengthen teachers' ecological-pedagogical preparation, to adapt methodological guides to the features of the local natural environment, and to align assessment criteria with the components of natural-science literacy. In future research, empirically measuring the relationship between the level of ecological-concept formation and indicators of natural-science literacy, as well as comparatively studying the experience of schools in different regions, remain among the pressing tasks.

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