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A Methodological Modeling of Preparing Future Primary School Educators in Natural Science Instruction in a Multilingual Environment

Gulnaz Kydyrbayeva [1], Assel Stambekova [1*], Saltanat Abdinazarova [2], Galiya Kulzhanbekova [2], Moldir Sultanmurat [3] and Gulvira Matzhanova [4]

[1] Institute of Pedagogy and Psychology, Department of Professional Training, Educational Program: «Primary education», Abai Kazakh National Pedagogical University, 13 Dostyk Ave., 050010, Almaty, Kazakhstan;
[2] Department of Foreign Languages, Al-Farabi Kazakh National University, 71 al-Farabi Ave., 050040, Almaty, Kazakhstan;
[3] Department of Foreign Languages, U. Dzhanibekov South Kazakhstan Pedagogical University, st. A. Baitursynova, 13, 160012, Shymkent, Kazakhstan;
[4] Foreign Languages and Translation Studies Department, Languages and Management Faculty, West Kazakhstan Innovative and Technological University, 194 Nazarbayev, 09000, Oral, West Kazakhstan;

Corresponding author*: e-mail: assel.stambekova@abai.edu.kz

ABSTRACT: This study focuses on the development and implementation of a comprehensive methodological model aimed at preparing future primary school educators for effective natural science instruction within the unique context of a multilingual environment. The research delves into the intricate intersection of science education, acknowledging the increasing multicultural landscape of primary classrooms. The methodological model is designed to address the specific challenges posed by multilingual settings, emphasizing the cultivation of educators' professional competencies in navigating and delivering impactful natural science content. This study presents a comprehensive model for preparing future primary school educators to teach natural science in multilingual classrooms, focusing on developing professional competencies to address these unique challenges. It explores theoretical foundations, practical strategies, and pedagogical tools to enhance educators' effectiveness in fostering students' understanding of natural science in multicultural environments. The outcomes of this research contribute valuable insights into enhancing the professional preparation of future primary school educators, fostering their ability to foster a meaningful understanding of natural science among students in multilingual educational settings.

Keywords: methodology, model, future primary school educators, multilingual environment, professional competences.

I. INTRODUCTION

In the contemporary context of societal progress, the professional training system for educators is distinguished by the requirement for teachers able of effectively designing the educational process to meet the needs of the school.

The current primary school system (grades 1-4) focuses on the State Curriculum's qualification criteria, emphasizing the pursuit of high-quality school education. The accomplishment of these objectives can be achieved through aligning educational content and technologies with humanistic priorities. Additionally, it involves considering age-related patterns of students development, their characteristics, and abilities during the primary school stage, within the student-centered learning content. Researchers like [2-4, 6, 9] played a crucial role in advancing the theory and methodology of teaching primary school students in natural science. These publications delve into some specific aspects of teaching methodology of natural science to primary school students.

The challenges within natural science education remain highly pertinent. Over the past two decades, numerous international conferences and symposia have been convened worldwide, addressing various aspects of natural science education at different levels. Notably, it has been underscored that societal natural science literacy is inadequate and is poised to become even more crucial in the 21st century. Early exposure to natural science education is instrumental in fostering and enhancing natural science literacy [1]. Broad changes are occurring in the landscape of natural science education, encompassing alterations in educational content, the quest for more effective

teaching methods, and the emergence of new societal needs. Undoubtedly, the significance of natural science education in shaping a child's personality is exceedingly high.

Undoubtedly, there is consensus that science education (SE) in primary school, despite being delivered in an integrated manner, should maintain a high standard. Simply put, primary school students ought to possess the capability to conduct basic observations and experiments, draw conclusions, utilize simple devices and instruments, and so forth. The gradual and purposeful development of students' abilities begins early, with foundational knowledge about nature imparted from the very first grade. This phase serves to cultivate certain skills, ultimately contributing to the formation of a naturalistic worldview [2].

Students in primary school, typically aged 6/7 to 10/11, actively acquire knowledge about the constant variability of nature, the surrounding natural and technological environment, and the alterations of materials under diverse influences. In essence, they gain comprehensive knowledge about the world around them, fostering the belief that the surrounding world is knowable. Science education encompasses diverse components, such as ecological awareness, environmental consciousness, healthy lifestyle practices, sustainable development principles, and more. Notably, engaging in experimental and research activities is of paramount importance. However, effectively integrating all these components into the primary educational process remains a challenge [2].

Numerous research studies highlight the challenges faced by primary school teachers in teaching natural sciences at this level. A prevalent issue is the apparent lack of interest among students in natural sciences or their relatively low level of engagement. Researchers caution that if such problems go unaddressed, they may negatively impact the quality of natural science education in subsequent stages of general education [3]. Scholars from foreign countries assert that there is limited understanding of teachers' perspectives on the goals, organization, and implementation of research activities, as well as their motivation to undertake more complex research endeavors [4]. It is evident that enhancing motivation and supporting teachers in these aspects is crucial for the improvement of science education.

The challenge in natural science education within multilingual environments lies in how primary school teachers conceptualize and deliver scientific content to diverse student populations. Understanding their perceptions is crucial for identifying key aspects of natural sciences at the primary level and translating them into effective, inclusive teaching practices. Furthermore, the ongoing issue persists when primary school teachers lack adequate preparation in the field of natural science education. Research findings indicate that many primary school teachers tend to avoid teaching natural sciences due to a lack of science knowledge and confidence in delivering science education . This problem is further aggravated by the fact that natural subjects should be taught in three languages: Kazakh, Russian and English.

The Purpose of this article is in the theoretical justification, development, and application of a methodological model designed to train primary school teachers in instructing elementary school students through the integrated course "The World Around Us" in Kazakh, Russian and English.This involves incorporating innovative professional methods and actively integrating the real-world environment into the educational process as a valuable source of information for primary school students.

II. METHODS AND MATERIAL

Our study employs a methodological modeling as the underlying research method. We have introduced a teaching model designed for future primary school educators in a multilingual setting. This model is developed through a systematic-structural analysis and elucidates the incorporation of its content across the natural science and methodological aspects of education within the content and procedural components.

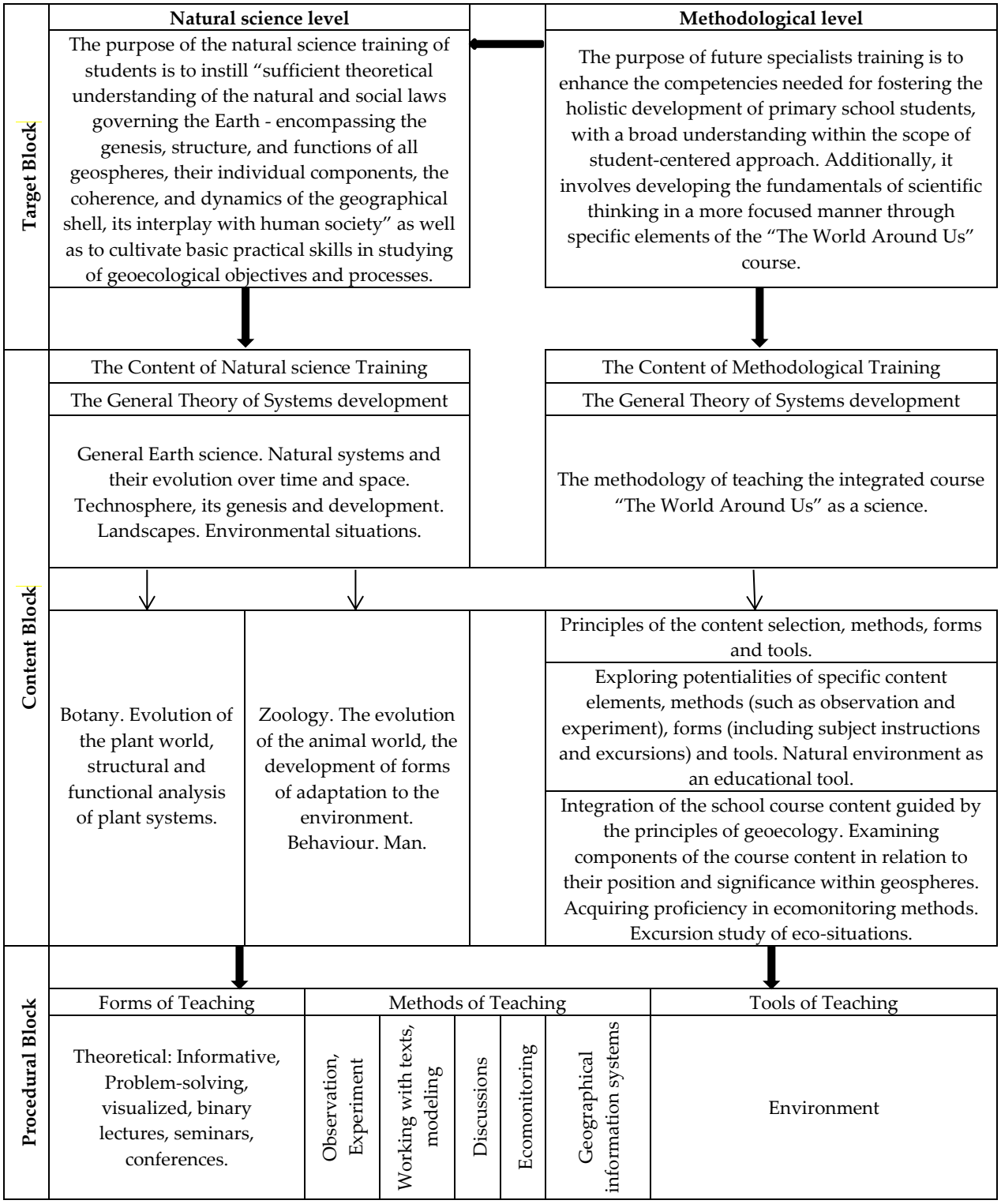
Generally, Modeling stands out as a crucial tool in addressing scientific challenges, finding extensive application across diverse disciplines. It enables the acquisition of dependable insights into the characteristics, evolution, and potential transformations of the subjects under investigation. In terms of its origin, the term "model" traces back to the Italian word "modello", derived from "modellus" in Vulgar Latin or "modulus" in Latin. These Latin terms, particularly the diminutive form "modulus", stem from the Latin word "modus" [6], signifying "measure, limit, boundary".

Shtoff (1966) [11], when discussing the usage of the term "model" in the context of science, highlights that its initial significance was linked to the art of construction. He observes that across nearly all European languages, the term was employed to denote a sample, prototype, or something sharing similarities with another object. The researcher notes that models represent a distinctive form of scientific abstraction, where the fundamental relationships of an object are visually captured and depicted through the connections and associations of material or iconic elements. This constitutes a synthesis of the particular and the universal, where aspects of a general and essential nature are prominently emphasized [4].

III. DATA COLLECTION

A Methodological Model of Preparing Future Primary School Educators in Natural Science Instruction within the framework of multilingualism (in Kazakh, Russian and English) serves both as an outcome of research endeavors and as a tool for conducting such research activities. The model is considered as a condensed (or generalized) representation of the methodological system for training students, aimed at implementing the educational process for primary school students in the course "The World Around Us" [5].

The depicted model in the figure 1 pertains to cognitive (specifically, figurative-iconic) or logical-semiotic categories, as it is formulated using distinctive signs, symbols, and structural diagrams.



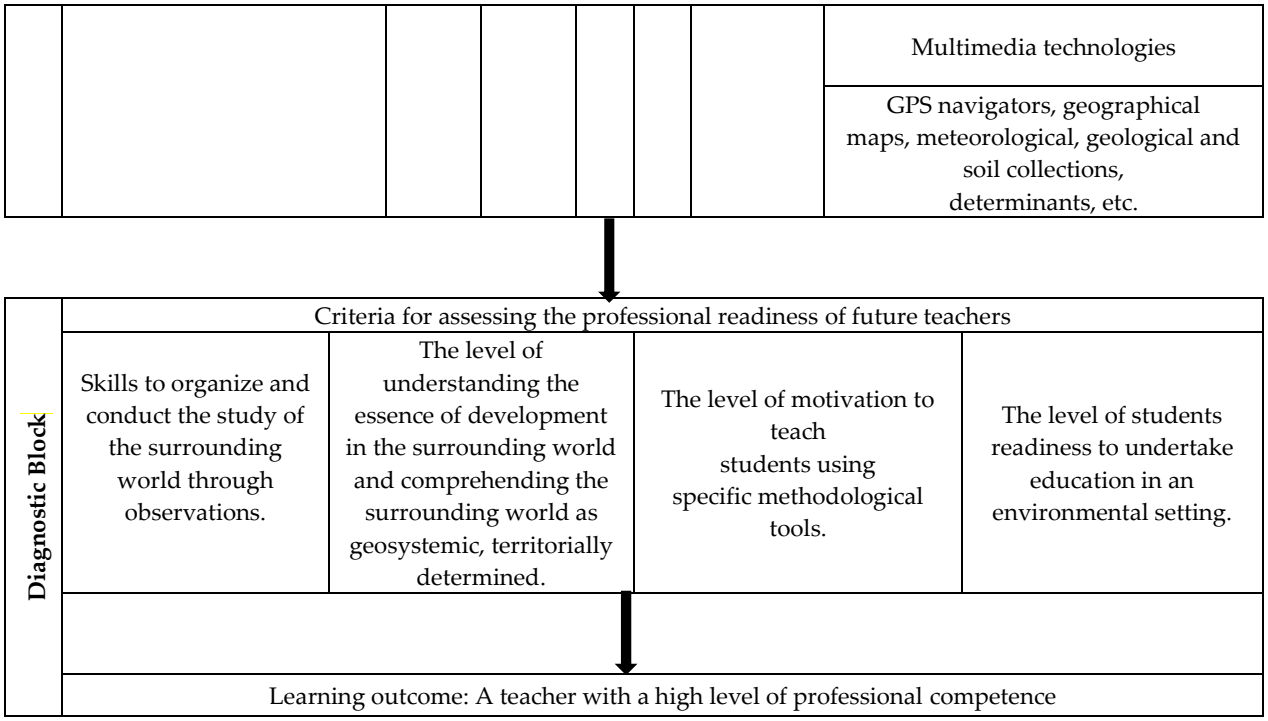


FIGURE 1. A methodological model of preparing future primary school educators in natural science instruction within the framework of multilingualism (in Kazakh, Russian and English)

The model is structured horizontally and vertically. Horizontal structuring is carried out across four blocks: Target, Content, Procedural and Diagnostic.

The Target Block is crucial and set in accordance with the demands of the educational curriculum related to professional competencies. It outlines the details of the methodological framework for training students through the "The World Around Us" course within the context of multilingualism. Within this block, the purpose of natural science education is tailored, establishing the orientation of methodological guidance [7].

The central part of the Model is the Content Block. It serves as the embodiment of the systems development theory. The focus of natural science education is on familiarizing students with the components of the surrounding world within Earth's geographical boundaries, coupled with an understanding of the ongoing processes within it. The surrounding world is conceptualized as a domain of systems operating at various levels, continuously evolving and delimited to specific territories [10].

Within the geographical component of the content (geography), students are presented with the geographical envelope depicted as a geosystem containing numerous subsystems. Among these, landscapes are emphasized as particularly pertinent to this field of professional education. In the biological segment of the content (botany and zoology), a more intricate exploration of the biosphere as one of the planet's geospheres is facilitated. Simultaneously, through the study of biological material, students are introduced to the fundamental processes of development [11].

The "Natural Science" course affords students the opportunity to delve into approaches to environmental issues. It underscores the insufficiency of confining environmental education solely within the realms of biotic ecology [8]. The notion of geoecology is introduced, wherein all processes occurring in geospheres, including landscapes, are interlinked, confined to specific territories, and indicative of a particular level of the environmental condition within that area. This concept is elucidated based on the idea of the environmental situation.

IV. DATA ANALYSIS

The methodological aspect within the Content Block of the model encompasses a fundamental theoretical course. Each element of the Content Block in the methodological course is scrutinized in terms of the imperative need for its elaboration within the geoecological framework. The model showcases an integrative mechanism for incorporating the content of the course "The World Around Us" on a local studies basis. This fosters an understanding of the potential methods, forms and tools essential for addressing this facet of students' education.

The Procedural Block within the model encompasses methods, forms, and tools utilized for the professional training of students. The lecture and seminar sessions involve active discussions and group methods, such as problem-solving discussions, binary lectures, "using guidebooks" and conferences. Among the primary educational tools, a notable emphasis is placed on primary sources and their analysis. When studying University textbooks, there is a deliberate effort to compare perspectives from various methodologists on the same topics, selecting the most effective approach for instructing primary school students.

The practical training of students stands out for the synergy of methods, forms, and tools, establishing specific subsystems within this educational domain. These are delineated as unique authorial methods through which conceptual principles are put into practical application.

Methodology of using objects and processes of the surrounding world as a source of information for students. This approach is founded on a natural science-oriented observation method. We have laid the foundation for a methodological system for educating students within a research setting, conceptualizing this process as the integration of various scientists' ideas into a unified structure. The methodology is rooted in observation, seen as an active means for students (and later, in their professional pursuits, for schoolchildren) to directly obtain firsthand information from objects and processes in the surrounding world. This involves the use of visual aids as well as the utilizing instruments and geographical maps.

We implement this methodology through modern active forms of student learning, including research projects and case studies. Throughout the academic year, students, in accordance with the Natural Science curriculum, observe climate changes, study phenological phenomena, and explore the anatomical, morphological, and ecological characteristics of plants and animals within the territory of their region. The assignments are crafted in a way that the answers to them can be primarily found through the investigation of specific real natural and social objects and phenomena. Each student completes several [3-6] individual research-based assignments for each section of the "Natural Science" course during one semester. Over the year, the total number of these assignments amounts to no less than 20. Additionally, assignments may be presented in three languages: Kazakh, Russian, or English.

Some case projects have a methodological aspect and involve collective projects to create multimedia presentations on natural science topics (spring phenomena in the plant world, anthropogenic impacts on soils, the ecological condition of a river, etc.). Implementing such a project involves a collective need to create a presentation plan and distribute roles, along with the ability to use digital technology to gather facts in nature and process them. It also requires the skill of synthesizing facts and providing textual support in the form of a comprehensive multimedia product [9].

Students conduct research of a similar level during the main methodological course. For this purpose, a system of tasks with methodological tips has been developed. Research projects are usually carried out by students during the period of theoretical training, pedagogical practices, and also when working on coursework and final qualification papers. These research endeavors have a specific focus aligned with the fundamental conceptual principles of the study. The spectrum of topics is broad and linked to the exploration of methods, forms, and tools of teaching to young learners.

1. *THE METHODOLOGY FOR STUDYING ENVIRONMENTAL SITUATIONS THAT CHARACTERIZE THE STATE OF LANDSCAPES*

Is carried out in the form of case studies, which serve as a collective research format. The subjects within the scope of students' understanding include landscapes and the ecological circumstances linked to them. This methodology is centered on the tasks of rendering the landscape and its ecological state comprehensible to students in a tangible way. In practical terms, students develop the ability to grasp the condition of the landscape by observing the influence of human activities on it, such as resource extraction, deforestation, the state of water bodies, soil composition, air pollution, alterations in topography, etc.

2. *METHODOLOGY TO INCORPORATING THE ENVIRONMENT AS A FACTOR IN PROFESSIONAL COMPETENCIES DEVELOPMENT.*

In this methodology, the environment is regarded as a fundamental educational tool, and its roles in student learning are examined from dual standpoints. On one hand, the environment functions as the subject of study and the space where students refine their investigative skills. On the other hand, the environment exerts its distinctive influence on individuals within it.

3. METHODOLOGY FOR EVALUATING THE PROGRESS OF CONCEPTS LINKED TO THE ENVIRONMENT.

This methodology enables students to acquire skills to perform direct and practical evaluations of the development of natural science concepts in schoolchildren. To achieve this, explicit tasks are incorporated into the educational framework, typically within research projects, involving activities such as drawing or coloring tasks and algorithmic tasks. These methodologies also serve as tools to gather feedback on the success of students' learning outcomes in the field of natural science.

The Diagnostic Block of the model incorporates a methodology to assess the established professional competencies of students using four criteria: skill to arrange and conduct the exploration of the surrounding world through observations; the level of comprehension regarding the essence of development in the surrounding world and recognizing it as geosystemic and territorially conditioned; the level of students' readiness to teach primary school students in an environmental context; and the level of motivation to teach primary school students using specialized methodological instruments.

Thus, a methodological model desighned by us is viewed as a complex system comprising several relatively independent subsystems of different ranks (blocks and levels).

V. RESULTS

Our methodological model was created and researched in order to improve the quality of training of specialists for primary schools in conditions of multilinguist. We identified the following set of competencies necessary for future primary school teachers to conduct "The World Around Us" course in three languages: Kazakh, Russian, and English:

1. Skills to use the outside world as a source of information for primary schoolchildren (through observation);
2. Understanding the essence of development in the surrounding world and comprehending the surrounding world as geosystemic, territorially conditioned;
3. Mastery of the system of educating young learners in the context of the surrounding environment;
4. The emergence of motivation for students' learning using specific methodological tools.

The experiment began with the ascertaining stage, aiming to study the features of the traditional training of future primary school teachers in the considered direction. Participants of the ascertaining stage included graduates of pedagogical colleges who underwent traditional methodological training in teaching natural sciences and began their education at a higher educational institution. Additionally, experienced primary school teachers who received higher education through a traditional scheme were also part of the participants. A total of 208 respondents were surveyed at this stage.

During the ascertaining stage of the experiment, professional competencies, as identified in our study, were measured.

1. SKILLS TO ORGANIZE AND CONDUCT THE STUDY OF THE SURROUNDING WORLD THROUGH OBSERVATIONS.

During the experiment, participants engaged in activities aligned with their skills: a) recognizing distinct characteristics of the subject under investigation, b) framing questions related to these characteristics, c) assigning a task involving the identification of signs, and d) providing explanations for the obtained results. The success in task execution was measured. The assessment of results was conducted using an alternative scale, where measurement indicators are placed into separate mutually exclusive categories. If a student identified observable features arbitrarily (randomly), formulated the question non-specifically, did not plan the fixation of results, and did not connect the analysis of results with conceptual thinking, then "No" was marked; in opposite cases, "Yes" was marked. The Efficiency Index (n) of professional training was calculated by determining the ratio between the number of respondents assessed with a "Yes" mark and the total number of subjects.

Table 1. Skills to organize and conduct the study of the surrounding world through observation

Criteria	Yes	No	N
Skill to identify features for observation	33%	67%	0,33
Skill in formulating questions for observation	17%	83%	0,17

Skill to provide tasks for recording observed features	24%	76%	0,24
Skill to explain the obtained results	0%	100%	0

We interpreted the obtained results in the following manner. Identification of features for observation was mostly spontaneous in the majority of cases. This was particularly evident when dealing with complex objects in terms of shapes and colors (the coloration of feathers on certain birds, the shapes of tree crowns, etc.), which were described spontaneously without the involvement of specialized knowledge. However, students failed to establish a connection between observation and understanding the world, and only 33% utilized the operation of comparison. Questions were more frequently formulated in a manner that implied answers unrelated to specific features. There were also completely abstract formulations, such as "Describe the appearance". The absolute difficulty lay in the necessity of explaining the developmental results of the observation. None of the respondents succeeded in completing this task.

The average Efficiency Index is 0.185, indicating a very low level of competence in utilizing the active natural science method in teaching.

2. UNDERSTANDING THE ESSENCE OF DEVELOPMENT IN THE SURROUNDING WORLD AND COMPREHENDING THE SURROUNDING WORLD AS GEOSYSTEMIC, TERRITORIALLY CONDITIONED

The materials for the test task on the second criterion were presented through three questions of an alternative scale choice. The respondents were required to: (A) characterize the ecological situation; (B) describe the concept of "environment"; and (C) select from a series of landscape formation factors (mountain rocks, relief, water regime, atmospheric influences, plants, animals, human activities) - the leading factors.

The obtained results (Table 2) can be interpreted as follows: Environmental situations were characterized in all cases in connection with the deterioration of the habitat, and the destructive activities of humans. This is a traditional approach to assessing the interaction between humans and nature. References to a favorable state of the environment were absent. However, in 14% of cases, we observed references to the territorial localization of environmental situations. Yet, this was not linked to a conceptual understanding but rather to a descriptive presentation of the response using examples characterizing a specific place, such as a city or a river. A typical thesis was: "The ecological condition of the air in the city is poor due to the abundance of traffic and the pollution from its industries".

Table 2. Understanding the surrounding world as geosystemic, territorially conditioned (ascertaining stage)

	Yes	**No**	**n**
Characteristics of the environmental situation	**22%**	**78%**	**0,22**
Characteristics of the concept of "surrounding world"	**5%**	**95%**	**0,05**
Factors of landscape formation	**32%**	**68%**	**0,32**

The concept of the Surrounding World was primarily associated with nature in a narrow sense of the word, regardless of the language, whether it be their native language or English. A broad understanding of it is noted in 5% of cases (with references to social objects, energy, information). For example: a definition was provided: "The surrounding world is everything that surrounds a person, including the person itself". Its components were listed as well (the sun, air, earth, rocks, plants, animals, and humans). Questions about whether substances like information stored in a computer, thoughts, light energy, potential energy, etc., are considered part of the surrounding world caused difficulties.

Analysis of the respondents' understanding of landscape formation factors showed that a large number of surveyed students choose one or several factors from the series. More frequently, the focus is on the human-made factor, and concurrently, characteristics such as topography, water conditions, and plants are observed. However, when interviewed about whether trophic interactions could characterize the landscape, students struggled to provide an answer. Therefore, students did not integrate the primary elements of the landscape and the connections

between them into a cohesive concept of these geosystems. The average Efficiency Index is 0.2 (20%), which is considered a low indicator.

3. MASTERY OF THE SYSTEM OF EDUCATING YOUNG LEARNERS IN THE CONTEXT OF THE SURROUNDING ENVIRONMENT.

This criterion was examined through interviews based on the rules of educating students in excursion conditions. An interview on the rules of conducting excursions included a series of questions:

1. Characterize the excursion as an educational form of organizing the educational-inquisitive process. The anticipated correct answer includes a description of the excursion as a form.
2. Name the key advantages of excursions over regular lessons.
3. What didactic rules need to be strictly followed during the excursion?

Additional information was obtained from the analysis of lesson plans, which were scrutinized in terms of implementing education for primary school students in a research environment. The test assignment required the creation of a lesson plan for an excursion specifically designed for exploring the surrounding world.

Table 3. The level of students' readiness to undertake education in an environmental setting.

Indicators	Yes	No	n
Knowledge of the rules for conducting excursions, considering the implementation of education in a research environment	51%	49%	0,51
The skill to create a plan, considering the execution of education within a research environment.	25%	75%	0,25%

VI. DISCUSSION

The analysis revealed that the understanding of excursions is perceived as a general educational form. The presumed correct response encompassed describing the excursion as a form wherein, under the guidance of a teacher, students independently acquire information from objects and processes in real-world interactions.

Additionally, it's worth highlighting that a typical excursion plan embodied a teaching method where students acquire a minimal amount of information from their surroundings, and the maximum amount of information is conveyed by the teacher through conversation (which are more summarizing than heuristic) and through explanations using real visual tools. Frequently, educational activities in the form of games were employed within the "Zone of Proximal Development".

The average Efficiency Index is 0.38, which characterizes the obtained results as quite low. The level of motivation to teach students using specific methodological tools. The respondents were provided with the chance to select information sources to teach young learners. The task included the question: "Select information sources for young learners that, in your opinion, play a leading role in their learning: A. Textbook, visual aids, audio-visual resources; B. Real-world environment".

The survey results revealed that respondents (41%) possess motivation for teaching in real-world conditions, which represents a smaller portion. In contrast, (59%) of respondents consider resources as leading tools of education. Thus, the results of the ascertaining experiment indicated low results across all four types of professional competencies.

The goal of the formative stage of the experiment was to test the described methodological model and to implement it for preparing specialists to teach the integrated course "The World Around Us" in the educational process. It led to the following outcomes. Students' readiness in utilizing the surrounding environment as an information source for schoolchildren has shown an average increase, observed to rise from 19% to 52% (Fig.2).

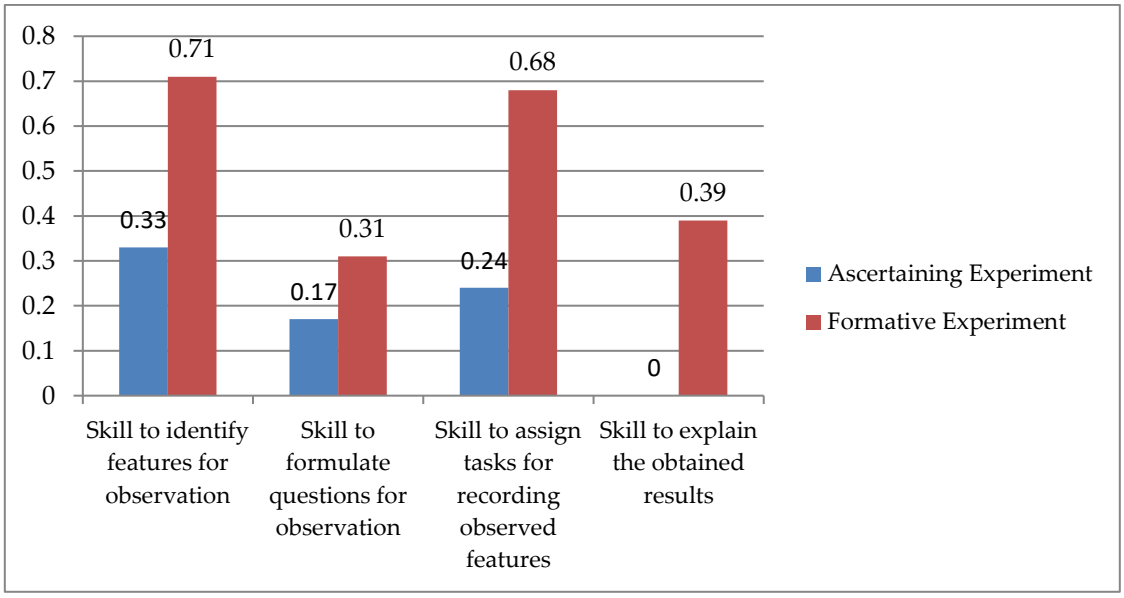


FIGURE 2. Enhancing students' readiness in utilizing the surrounding world as a source of information for young learners (comparing efficiency indices).

1. There is an increase in students' readiness in understanding the mechanism of development. In the descriptive part, they only dealt with the empirical characteristics of this process (98%), but as a result of the training, a larger number of students (69%) began to characterize this process from the perspective of its essence.
2. There is an increase in students' readiness in understanding the surrounding world as geosystemic, territorially conditioned, which has changed from 20% to 80% (Figure 3).

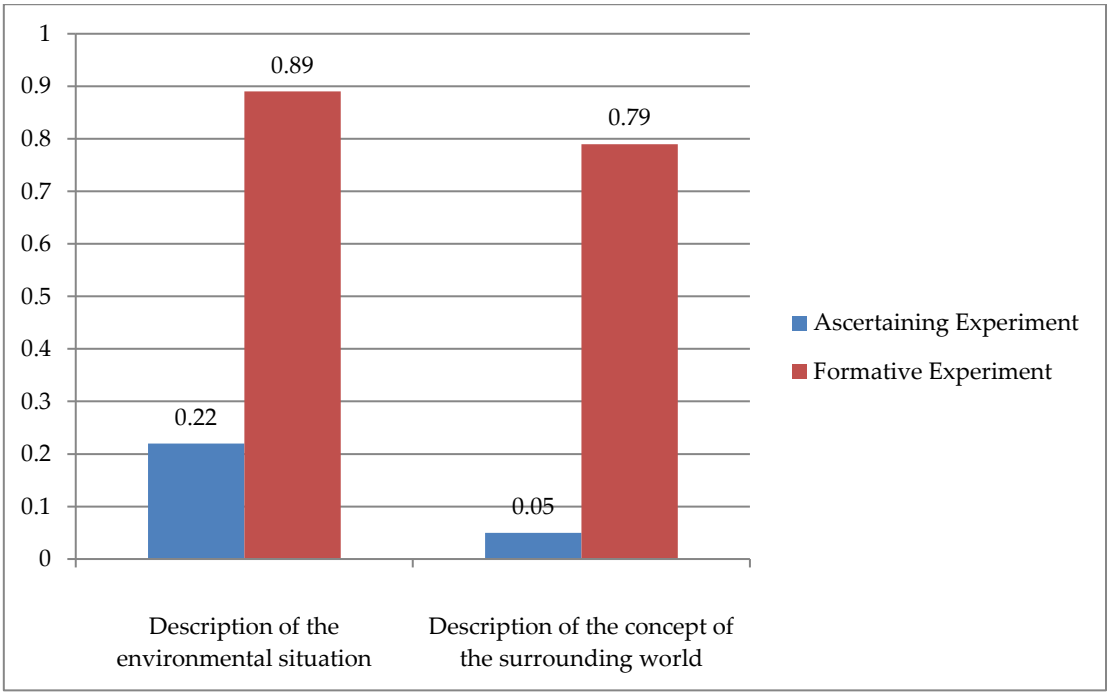


FIGURE 3. Enhancement of students' readiness in understanding the surrounding world as geosystemic and territorially conditioned (comparison of efficiency indices).

1. The indicator of students' rediness for conducting education in environmental conditions increased from 38% to 79% (Fig. 4).

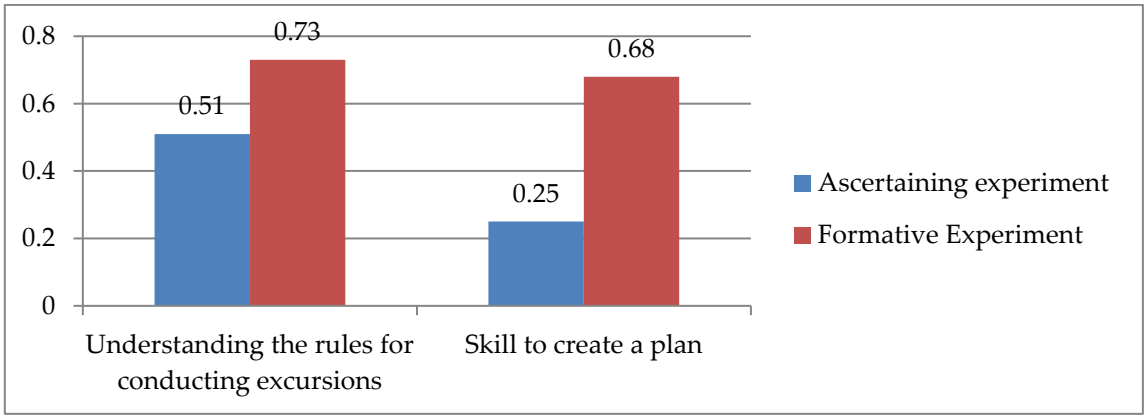


FIGURE 4. The level of students' rediness for conducting education for younger schoolchildren in environmental conditions (comparison of the efficiency index).

2. A trend has emerged indicating a shift in motivation for teaching young learners in the context of the surrounding world. It is noted that 48% of students made the preferable choice of the real surrounding world as the learning environment, compared to 41% in the ascertaining experiment (Fig. 5).

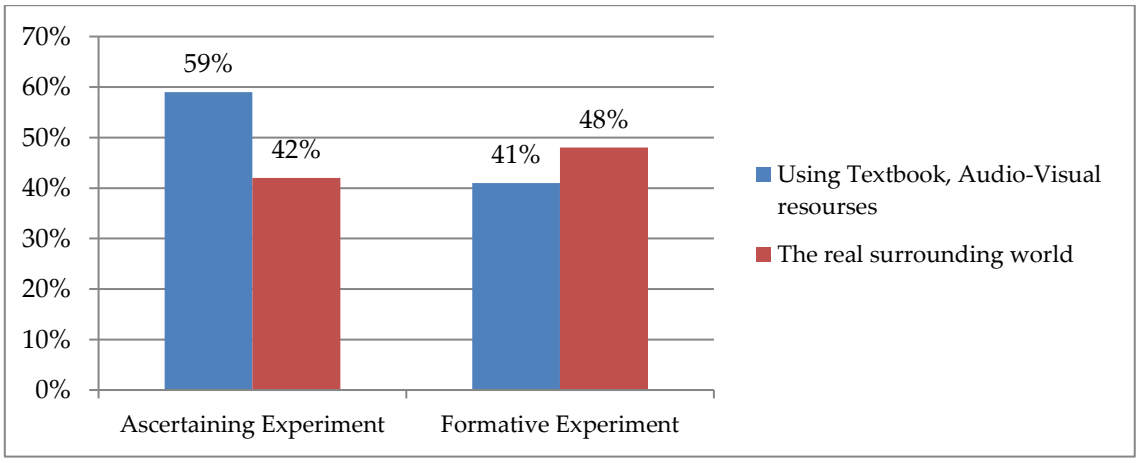


FIGURE 5. Change in motivation regarding the selection of information sources in teaching young learners (comparison of data between the ascertaining experiment and the formative experiment).

Thus, the results of the experiment on implementing the methodological model for preparing students of the pedagogical university for teaching younger learners the course "The World Around Us" in the multilingual educational process confirm the validity of our purpose.

VII. CONCLUSION

Key findings from this study include the development of a comprehensive methodological model for preparing future primary school educators to teach natural science in multilingual environments. This model integrates fundamental natural science disciplines through targeted, content-based, procedural, and diagnostic components, effectively enhancing teachers' professional competencies. Additionally, the research identified the theoretical basis for training educators to deliver the integrated course "The World Around Us," emphasizing the importance of fostering a scientific worldview in young learners.

VIII. RECOMMENDATIONS

1. Educators should adopt the system-based approach outlined in the model to enhance their readiness for teaching natural science in diverse, multilingual classrooms.
2. Policymakers should consider integrating the model's framework into teacher training programs to ensure future educators are equipped to navigate the complexities of multilingual learning environments.
3. Curriculum developers should align instructional resources with the model's principles to better support natural science instruction in multilingual primary settings.

In conclusion, the successful application of this methodological model demonstrates its potential to transform the professional preparation of future primary school educators. Further research could explore its broader applicability across different educational contexts, offering new pathways for enhancing natural science education in multicultural classrooms.

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Author contribution

All authors made an equal contribution to the development and planning of the study.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data are available from the authors upon request.

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