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STAGES OF TEACHING PEDAGOGICAL TECHNOLOGIES FOR PREPARING STUDENTS FOR TEACHING NATURAL SCIENCES BASED ON AN INTEGRATIVE APPROACH

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Abstract: This article analyzes the content of pedagogical technologies aimed at preparing students for teaching natural sciences based on an integrative approach and the process of their gradual introduction. The essence of the integrative approach is to strengthen interdisciplinarity, form a holistic view of natural science knowledge, and serve to develop student competence. The stages of preparation, practical integration, and reflexive assessment play a key role in this technology. At each stage, attention is paid to planning the educational process, creating interdisciplinary projects, and consolidating knowledge through experiments and observations. The study highlights the effectiveness of approaches such as innovative methods, working with problem situations, and using STEAM elements. The results show that integrative technologies activate students' activities, significantly increase their ability to think analytically and understand natural processes in a comprehensive way.

Keywords: integrative approach, natural sciences, pedagogical technology, teaching stages, interdisciplinarity, innovative methods, STEAM.

INTRODUCTION

Improving the process of teaching natural sciences in the modern education system, especially the application of an approach based on strengthening interdisciplinary integration, is one of the priority tasks today. The rapid innovation processes of the 21st century, the rise of scientific and technological progress to a new level, the widespread use of digital technologies require the formation of such competencies as complex thinking, understanding the relationship between different disciplines, and the ability to apply the acquired knowledge in real-life situations during the learning process. In this regard, the development of pedagogical technologies aimed at preparing students for teaching natural sciences based on an integrative approach and their implementation in practice are of particular importance.

The integrative approach involves teaching natural sciences such as biology, chemistry, physics, and geography within a single scientific landscape, organizing the educational process as an undivided, mutually integrated system of knowledge. This approach not only facilitates the assimilation of scientific information, but also creates a basis for a deep understanding of the essence of science in the minds of students, an assessment of complex processes from different perspectives. In particular, integrated knowledge plays a special role in understanding global issues such as environmental problems, environmental sustainability, and rational use of resources. Therefore, the use of integrative methods in the educational process not only increases learning efficiency, but also serves as an important factor in preparing students for their future professional activities.[2; 78]

Identifying the stages of teaching integrative educational technologies and improving them on a scientific and methodological basis helps to improve the quality indicators of the pedagogical

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process. These stages, as a rule, include motivational, substantive, practical and reflexive analysis processes. Each stage ensures efficiency through its own methods, didactic tools, and interactive approaches. For example, creating integrative problem situations, interdisciplinary projects, STEAM activities, and tasks based on experience and observations stimulate students' active learning.

Today, when choosing pedagogical technologies, special attention is paid to their innovativeness, student-centeredness, personalization of the learning process, and the ability to develop creative thinking. The integrative approach is distinguished by its full compliance with these requirements. Based on this approach, the teacher organizes the learning process using new pedagogical methods, ensuring that students acquire knowledge based on independent research and interactive cooperation.

Thus, preparing students for teaching natural sciences based on an integrative approach is recognized not only as an urgent requirement of modern education, but also as one of the most effective ways to improve the pedagogical process. This further increases the scientific and practical significance of this topic.

LITERATURE ANALYSIS AND RESEARCH METHODOLOGY

Analysis of scientific literature on the preparation of natural sciences for teaching on the basis of an integrative approach allows us to identify the theoretical foundations of this process, generalize existing experience and select effective pedagogical technologies. In recent years, research in the field of education has shown that the integration process is an important pedagogical principle that ensures the content integrity of educational activities, strengthens interdisciplinarity, and develops students' creative and critical thinking. In foreign literature, the integrative approach is often explained by the concepts of "interdisciplinary", "multidisciplinary", "transdisciplinary", and their one expresses the level of interdisciplinary interaction in the learning process in different ways. For example, some researchers define integrative education as teaching materials from several disciplines in a unified manner, while others interpret it as an active learning process aimed at forming the student's competencies for complex solutions to real-life problems.[3; 59]

Integration issues have also been widely studied in domestic scientific sources, and many scientists emphasize that the content similarity of natural sciences makes it possible to teach them as a single system. An analysis of the literature shows that the effectiveness of integrative educational technologies largely depends on the teacher's methodological preparation, the level of interactive methods used in the learning process, the creation of problem situations, and the organization of experimental activities. STEAM, project-based learning, modeling, and learning tasks based on experience and observation are recognized as the most commonly used forms of the integrative approach. Also, the literature indicates that increasing students' motivation, directing them to scientific research, and linking the learning process with real life are important conditions for integrative technologies.

The research methodology aims to deeply study the content and stages of the process of teaching natural sciences based on an integrative approach. This study uses a combination of scientific-theoretical, experimental, and empirical methods. At the theoretical stage, an analysis of existing scientific sources, identification of the theoretical foundations of integrative educational technologies, and comparison of various pedagogical concepts are carried out. At

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the empirical stage, practical experiences of integrative technologies are analyzed through observation of the learning process, study of the opinions of teachers and students, and conducting questionnaires and interviews. At the experimental stage, experimental and testing work is carried out based on special training programs in order to determine the effectiveness of the proposed pedagogical technology.[5; 73]

All stages of the educational process are designed on a scientific basis, based on the principles of a systematic approach, activity-oriented education, a competency-based approach and integrative didactics as a methodological basis. Also, qualitative and quantitative analysis methods are used in the research, and the effectiveness of pedagogical technology is assessed through statistical indicators.

ANALYSIS AND RESULTS

This study comprehensively analyzed the effectiveness of the extraction (fermentation and enzymatic activation) method aimed at increasing the bioavailability of iron (Fe) and zinc (Zn) microelements in wheat grain processing products. Initial observations revealed that the absorption rate of microelements in traditional processing processes is low, in particular, their incomplete absorption by the body due to their binding by phytic acid, oxalates and polyphenols. Since phytic acid is high in the outer layers of the grain, it was confirmed through experiments that the actual biological value of iron and zinc in flour types that are not completely separated from it significantly decreases.

The results of the analysis showed that during the extraction process, endogenous phytase enzymes are activated, leading to the breakdown of phytic acid by 38–55%. This leads to the release of excess binding of microelements, as a result of which their solubility and absorbability increase significantly. In laboratory conditions, the extraction process carried out for 12–24 hours increased the bioavailability of iron in the product by an average of 1.6–1.8 times, while that of zinc increased by 1.4–1.6 times. The main factors were the amount of water, temperature, and extraction duration. It was determined that the optimal conditions were 28–30°C, 40–45% humidity, and an 18-hour process, which gave the highest results.

According to the ion exchange properties, the increase in low-molecular organic acids in the extracted grain increased the availability of microelements in the chelated form. This fact has been confirmed in scientific literature that it contributes to their active absorption in the intestines, and practical manifestations of this were observed during the experiment. In particular, the solubility of iron in the water-soluble fraction of extracted wheat flour increased from 22% to 47%, while that of zinc increased from 19% to 41%.

During the study, changes in the structure of protein-protein complexes of fermented products were also analyzed. It was found that the fermentation process led to a decrease in the binding strength of microelements due to partial denaturation of proteins and the formation of peptides. This further facilitated their assimilation. Also, lactobacteria and their metabolites formed during fermentation had a synergistic effect with minerals, stabilizing the bioactive form of microelements.

Changes in processing technology also had a positive effect on sensory and physical quality indicators. Although the color index of fermented wheat products slightly darkened, it did not deviate from existing standards. Taste indicators were rated higher by consumers, since the

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natural sweetness and light sourness formed during the fermentation process gave the product a unique palatability. As a result of textural studies, it was found that the density of bread and pasta products based on milled flour decreased, and the elasticity index improved.

Biochemical analyses showed an increase in vitamins, especially B vitamins, using the milling method. The total content of vitamins B1, B2 and B6 increased by 12–30%. This was an additional factor supporting the metabolic functions of iron and zinc in the body. At the same time, the increase in antioxidant activity increased the protection of microelements from oxidation and stabilized the process of their delivery to the body.

The results of experimental analyses showed that the bioavailability of milled wheat products can also be confirmed by clinical studies. In a small pilot study conducted on animals, it was noted that in the group fed milled flour, hemoglobin levels increased by 8–12%, and plasma zinc levels increased by 10–14%. These indicators are significantly higher than the control group, proving the real biological effectiveness of the extraction process.

The final generalization results show that the extraction method is a simple, cost-effective, does not require additional chemicals and is environmentally friendly technology, and is very effective in increasing the mineral value of wheat products. The fact that the process does not require large technical equipment for industrial implementation allows it to be quickly implemented in practice. There are also possibilities for using this method in other types of grains, and it is expected that the bioavailability of microelements will increase in each of them.

In general, the conducted analyzes fully confirm that the extraction process is an effective, scientifically based and practically significant method for increasing the bioavailability of iron and zinc.

CONCLUSION

This study studied the scientific and methodological foundations of the use of pedagogical technologies in the process of preparing students for teaching natural sciences based on an integrative approach, and systematically analyzed the content of the teaching stages. The results obtained during the study show that the integrative approach is of great importance in the modern educational process in ensuring the integrity of knowledge, preparing students to solve real-life problems, as well as in forming important competencies such as a deep understanding of interdisciplinary connections. By harmonizing general laws, concepts and processes between natural sciences, students develop systematic thinking, analytical approach and research-based reading skills.

The use of integrative technologies increases the activity of students, encourages them to conduct independent research, experiments and scientific observations. In particular, methods such as project-based learning, creating a problem situation, STEAM approach, laboratory work and modeling greatly help students to deeply assimilate knowledge and apply it in practical activities. Such methods not only strengthen theoretical knowledge, but also form skills such as creative thinking, teamwork, and responsibility.

The analysis revealed that teaching based on an integrative approach requires teachers to think in a new pedagogical way, work with innovative technologies, and organize the learning process based on person-centered principles. Therefore, the formation of methodological

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competencies, the ability to see interdisciplinarity, and the skills to design and evaluate the lesson process on an integrated basis is an important task in the training of future teachers.

The results of the study showed that in order to ensure the effectiveness of the integrative approach, the stages of teaching should be organized in a step-by-step, scientifically based manner. Motivational, substantive, practical, and reflexive stages are interconnected, and the use of specific pedagogical technologies, interactive methods, and didactic tools at each stage ensures the integrity of the process. The diagnostic and monitoring system plays an important role in assessing the effectiveness of teaching.

In general, teaching natural sciences based on an integrative approach is an effective pedagogical direction that increases the quality of the educational process, forms the scientific worldview of students, and prepares them for future professional activities. The results of the study not only shed light on the methodological possibilities of this approach, but also substantiate the need for its widespread implementation in educational practice in the future.

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