BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg
BG PULSE JOURNAL

PRACTICAL RESULTS OF IMPROVING THE METHODOLOGY OF TEACHING BOTANY THROUGH AN INTEGRATIVE APPROACH IN PEDAGOGICAL HIGHER EDUCATION INSTITUTIONS

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Introduction

In the modern higher education system, the rapid advancement of science, the dramatic increase in information flow, and the intensification of interdisciplinary integration processes are imposing new demands on the content of education and the methodology of its organization. From this perspective, improving the methodology of teaching *Botany*, which constitutes an essential component of biological education, has emerged as one of the pressing pedagogical challenges. Interdisciplinary integration contributes to the formation of students' knowledge not as a collection of isolated facts but as a coherent and interconnected system. As a result, students develop the ability to analyze natural phenomena comprehensively, identify cause-and-effect relationships, and integrate theoretical knowledge with practical application.

An educational process organized on the basis of an integrative approach creates favorable conditions for developing students' analytical and critical thinking skills, broadening their scientific worldview, fostering independent learning, and cultivating competencies necessary for making effective decisions in problem-solving situations. In particular, teaching Botany in close connection with Ecology, Genetics, Plant Physiology, Biochemistry, Molecular Biology, and other biological disciplines ensures a deeper and more systematic understanding of the plant world and its underlying processes.

During the course of the research, the scientific-theoretical and methodological foundations for teaching Botany through an integrative approach in higher education institutions were thoroughly examined, and a comprehensive pedagogical system aimed at enhancing the effectiveness of this process was developed. Specifically, a conceptual and methodological model based on the principles of interdisciplinary integration was designed; a set of interactive teaching methods focused on the use of modern pedagogical and information-communication technologies was proposed; and mechanisms for introducing integrative laboratory activities into the educational process were elaborated.

The developed methodological system promotes students' active participation in the learning process, facilitates the integration of theoretical knowledge with practical activities, stimulates interest in scientific research, and contributes to the development of professional competencies. Furthermore, the proposed methodology serves as an important tool for fostering students' creative thinking, research skills, environmental awareness, and professional responsibility.

Consequently, the improved model of Botany education based on an integrative approach provides a solid scientific and methodological foundation for enhancing the quality of training of Biology students, developing their research competencies, preparing competitive specialists capable of meeting the demands of the contemporary labor market, and increasing the overall effectiveness of teaching biological sciences within the higher education system.

Methods

The primary objective of the experimental study was to determine the practical effectiveness of theoretically substantiated ideas, proposals, and recommendations aimed at improving the methodology of teaching *Botany* through an integrative approach, as well as to evaluate their impact on the educational process. To achieve this objective, the following tasks were identified:

– to determine and comparatively analyze the advantages of teaching methods and technologies developed on the basis of an integrative approach over traditional teaching methods;

– to investigate the dynamics of students' theoretical knowledge of Botany, practical skills, creative thinking abilities, and learning motivation;

– to evaluate the pedagogical effectiveness of the improved methodology using mathematical-statistical analysis and qualitative indicators;

– to develop scientific and methodological recommendations for the large-scale implementation of the integrative approach in the practice of higher education institutions based on the research findings.

No.	Stages	Description of the Stages	Activities Implemented
1	**Exploratory (Diagnostic-Assessment) Stage (2023–2024)**	Assessing and evaluating students' initial level of knowledge in Botany, readiness for an integrative approach, motivation, and relevant skills.	– A comprehensive review of literature related to the research topic was conducted; – Questionnaires and surveys were administered to students and instructors; – Traditional classroom teaching processes were observed; – Experimental and control groups were selected; – Initial diagnostic tests were conducted and the results were subjected to statistical analysis.
2	**Formative (Educational-Transformative) Stage (2024–2025)**	Implementing a new methodology based on an integrative approach; developing students' in-depth botanical knowledge, creative thinking, and practical skills through interdisciplinary connections.	– Classes in the experimental groups were conducted using integrative teaching methods; – Traditional teaching methodology was applied in the control groups; – Seminars and training sessions were organized; – Intermediate results were collected and analyzed.
3	**Control (Final-Summative) Stage (2025–2026)**	Comparing the obtained results with the initial findings, validating the effectiveness of the integrative approach, and developing practical recommendations.	– Final results were compared with the initial findings and comprehensively analyzed; – The reliability and effectiveness of the integrative methodology were confirmed through statistical methods; – Practical recommendations were developed, systematized, and generalized.

Table 1. Stages of the Experimental Study on Improving the Methodology of Teaching Botany through an Integrative Approach in Pedagogical Higher Education Institutions.

The methodological foundation of the experimental study was based on the principles of systematicity, consistency, continuity, and coherence. These principles ensured the integrity of the educational process, facilitated the observation of the step-by-step development of learning activities, and enabled the systematic formation of students' competencies. During the research, the parallel-group model of pedagogical experimentation was employed, allowing for comparative analyses between the experimental and control groups. The study utilized a range of research methods, including pedagogical observation, interviews, questionnaires, achievement tests, expert evaluation, pedagogical experimentation, and mathematical-statistical analysis.

Results

Within the framework of the study, a stage-by-stage model for organizing the teaching of Botany through an integrative approach was developed and implemented in educational practice. The model consisted of preparation, implementation, and final evaluation stages, with clearly defined objectives, tasks, methods, and expected outcomes for each stage.

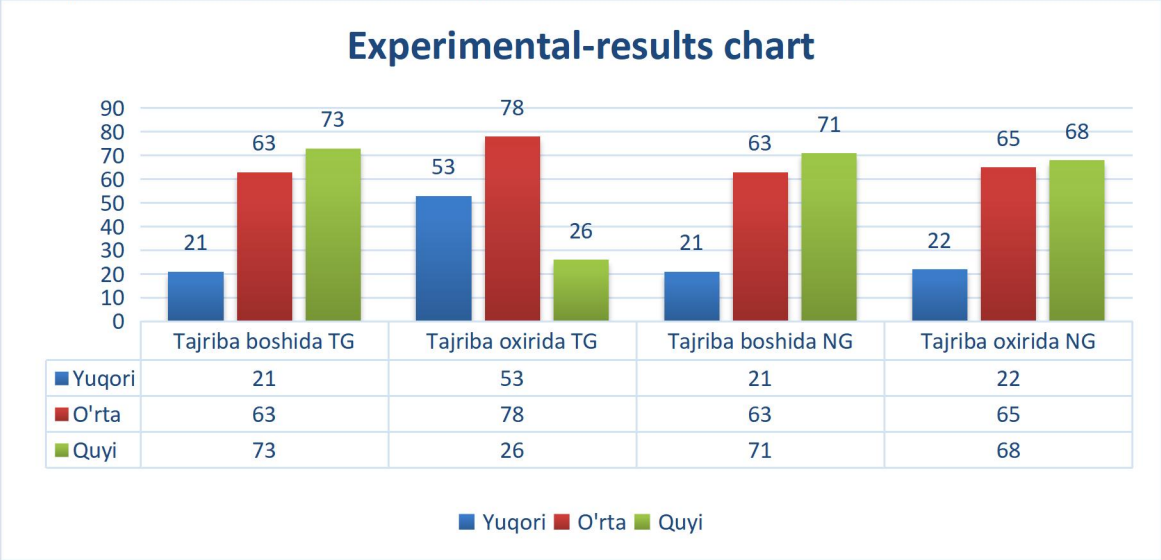


Table 2. **Results of the Experimental Research.**

Based on the developed framework, integrative lectures, practical classes, and laboratory activities were introduced into the educational process. The instructional activities were organized around the interrelationships between Botany and other biological disciplines, including Ecology, Genetics, Plant Physiology, and related fields. This approach facilitated students' systematic acquisition of knowledge, enhanced their understanding of interdisciplinary connections, and contributed to the development of competencies for applying theoretical knowledge in practical contexts.

The results of the experimental study demonstrated that students participating in the integrative learning environment showed significantly higher levels of academic achievement,

independent thinking, creative engagement, and learning motivation compared with those in the control groups. The obtained data were processed using mathematical-statistical methods, and the pedagogical effectiveness of the proposed methodology was reliably confirmed.

Furthermore, the findings revealed that the application of an integrative approach in teaching Botany serves as an important factor in the development of professional and research competencies among Biology students. The study confirmed that interdisciplinary integration not only enhances subject-specific knowledge but also contributes to the formation of critical thinking, problem-solving abilities, and the skills necessary for successful professional and scientific activities.

Analysis

The experimental study was conducted at four pedagogical higher education institutions located in different regions of the country. The selection of research sites was based on several criteria, including broad geographical representation, the pedagogical specialization of the institutions, their experience in training Biology teachers, and the status and level of development of the Botany teaching process.

Students majoring in Biology participated in the experimental study. To ensure the objectivity and reliability of the research findings, equivalent experimental and control groups were formed at each institution. The formation of these groups took into account students' initial level of knowledge, academic performance, and level of participation in educational activities.

In the control groups, the educational process was organized according to existing curricula and traditional teaching methods. These included lectures, practical classes, laboratory activities, and independent learning assignments. In contrast, the experimental groups were taught using a methodological system based on an integrative approach that had been scientifically and theoretically substantiated during the course of the study.

Content and Implementation of the Experimental Study

During the experimental process, a comprehensive instructional and methodological package aimed at teaching Botany through an integrative approach was developed and implemented in educational practice. This package included methodological materials designed to reveal the interrelationships between Botany and other natural science disciplines.

Specifically, lesson plans integrating Botany with Ecology, Chemistry, Geography, Genetics, and Information Technologies were developed. Laboratory activities promoting interdisciplinary connections were designed, while problem-based tasks and case-study materials were prepared. In addition, modern digital technologies, including mobile applications for plant identification and classification, electronic atlases, virtual laboratories, and interactive educational platforms, were actively incorporated into the teaching process.

In the experimental groups, instruction was organized using the following integrative methods:

- conducting comprehensive laboratory activities that demonstrated the relationship between Botany and Ecology;
- implementing experiments based on the integration of Botany and Chemistry to study the chemical composition and physiological processes of plants;
- organizing students' independent research activities through project-based learning;
- developing skills for analyzing professional situations through problem-based learning and case-study technologies;
- identifying plant species and analyzing their morphological and ecological characteristics using digital technologies;

• organizing collaborative learning activities in small groups and implementing interdisciplinary projects.

In the control groups, instruction was conducted using a traditional pedagogical approach, consisting of lectures, practical classes, laboratory activities, and independent learning assignments.

Throughout the experimental study, changes in students' theoretical knowledge, practical skills, research competencies, creative thinking abilities, and learning motivation were continuously monitored. The obtained data were comparatively analyzed across the experimental and control groups, providing evidence for evaluating the pedagogical effectiveness of the methodology developed on the basis of an integrative approach.

At the conclusion of the study, the results obtained from both the experimental and control groups demonstrated the success of the instructional process. The findings indicated that teaching Botany through an integrative approach significantly contributed to the development of students' independent thinking, understanding of interdisciplinary relationships, and professional preparation in the field of Botany.

Conclusion

The comparative analysis of the results obtained from the pedagogical experimental study conducted in the experimental and control groups confirmed the effectiveness of the methodology for teaching Botany through an integrative approach. The findings demonstrated that the integrative approach serves as an important pedagogical factor in deepening students' theoretical knowledge, developing independent and critical thinking skills, enhancing their understanding of interdisciplinary relationships, and fostering professional competencies.

During the initial stage of the experimental study, students' levels of knowledge, understanding of interdisciplinary connections, and learning motivation were assessed through diagnostic tests, questionnaires, and observation methods. Their baseline indicators were subsequently subjected to comparative analysis. Throughout the study, a methodological system based on integrating Botany with Ecology, Chemistry, Geography, and Information Technologies was implemented in the experimental groups.

The results revealed that the use of problem-based learning, project-based learning, case-study technology, integrative laboratory activities, and digital educational tools had a significant positive impact on students' systematic acquisition of knowledge, their ability to apply knowledge in practical situations, and their interest in research activities. Compared with the control groups, students in the experimental groups demonstrated higher levels of academic achievement, interdisciplinary thinking, analytical reasoning, and professional preparedness.

The findings further indicated that teaching Botany through an integrative approach contributes to the development of ecological, chemical, and information-technological thinking, facilitates the integration of theoretical knowledge with practical application, and promotes the formation of competencies required for modern professional activities. Moreover, this approach proved effective in enhancing students' learning motivation, developing independent learning skills, and expanding their ability to apply interdisciplinary knowledge in an integrated manner.

Thus, the implementation of a methodology for teaching Botany through an integrative approach in higher education institutions has been scientifically and practically substantiated as one of the important factors in improving the quality of Biology teacher education, developing students' research competencies, and increasing the overall effectiveness of the educational process.

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