CONTENT AND PECULIARITIES OF TEACHING "PLANT PHYSIOLOGY" IN HIGHER EDUCATION INSTITUTIONS BASED ON AN INTEGRATIVE APPROACH

Kholikulova Gulchehra *
Shahrisabz State Pedagogical Institute*

ANNOTATION: This article is dedicated to studying the theoretical and practical aspects of teaching the "Plant Physiology" course in higher education institutions based on an integrative approach. The study analyzes interdisciplinary integration, the alignment of theory and practice, the role of laboratory and experimental activities, as well as problem-based and research-oriented pedagogical strategies. The results of the study demonstrate the potential to develop students' scientific thinking, analytical and research competencies, and the ability to integrate theoretical knowledge with practical application, as well as to improve modern biology education. Moreover, the study outlines directions for adapting biology education to contemporary requirements through the application of STEAM approaches and interdisciplinary integration in practice. The findings serve as a valuable resource for organizing pedagogical processes effectively and enhancing students' scientific potential.

KEY WORDS: plant physiology, integrative approach, interdisciplinary integration, theory-practice alignment, research-oriented approach, STEAM education, scientific thinking, analytical competence, biology education.

INTRODUCTION

In the context of current globalization and scientific progress, the process of training specialists in higher education is continuously being improved through innovative approaches. In particular, in teaching natural sciences, it is crucial to integrate modern scientific achievements into the educational process, harmonize theoretical knowledge with practical activities, and develop students' research skills. Within the system of biological sciences, the course "Plant Physiology" holds a special place, as it not only explains the mechanisms of vital processes in living organisms but is also directly connected with agriculture, ecology, biotechnology, and environmental protection. Therefore, teaching the content of this course using modern pedagogical approaches represents one of the most important tasks facing higher education today.

The "Plant Physiology" course is one of the core theoretical subjects in the training of biology specialists. It focuses on studying the physiological basis of processes occurring in plant organisms, such as photosynthesis, respiration, metabolism, growth, and development. Through this course, students acquire systematic knowledge about the functional structure of plants, their interactions with environmental factors, and the laws governing biological processes. Moreover, the course is closely interconnected with related disciplines such as biology, botany, biochemistry, genetics, ecology, and molecular biology, thereby fostering a comprehensive scientific worldview among students.

In recent years, special attention has been paid to pedagogical approaches aimed at strengthening interdisciplinary connections and facilitating the acquisition of knowledge in a systematic and integrated manner. The integrative approach enables the identification of inherent links between different disciplines within the learning process, harmonizes theoretical knowledge with practical activities, and promotes the development of students' independent thinking and problem-solving competencies. Particularly in studying complex biological processes such as plant physiology, the use of an integrative approach allows students to comprehend physiological phenomena within a broader scientific context and analyze them in relation to other natural sciences. From this perspective, improving the content of the "Plant Physiology" course and developing a methodology for teaching it based on an integrative approach in higher education institutions represents a pressing scientific and pedagogical challenge.

Based on the considerations outlined above, the primary aim of this research is to analyze the content characteristics of the "Plant Physiology" course in higher education and to explore the pedagogical

possibilities of teaching it using an integrative approach. The study identifies the following objectives: to determine the role of the plant physiology course in biology education, to analyze the specific features of its content, to elucidate the pedagogical essence of the integrative approach, and to highlight the main characteristics of teaching this course in an integrated manner.

Main Part. Plant physiology is one of the key scientific disciplines within the system of biological sciences, focusing on the study of the laws governing vital processes in plant organisms. This field scientifically investigates plant survival, growth, development, and adaptation mechanisms to environmental factors. Plant physiology examines the interconnections of physiological processes ranging from the cellular level to the whole organism, including the exchange of substances and energy. In this respect, it is considered a fundamental biological science that explains the functional activity of plants.

The subject of plant physiology involves studying the mechanisms of physiological processes occurring in the plant organism, their interactions with the external environment, and the regulatory principles governing these processes. The course analyzes, on a scientific basis, metabolic processes in plant cells, water and mineral nutrition, photosynthesis, respiration, growth, and development. In addition, the plant's responses to environmental factors such as light, temperature, humidity, and mineral availability are examined within the scope of this discipline. One of the main objectives of plant physiology is to reveal the theoretical foundations of vital processes, determine their interrelationships, and provide a scientific basis for applying this knowledge in practical fields.

Various physiological processes in the plant organism occur in a coordinated and interconnected manner. Among the most important of these are photosynthesis, respiration, transpiration, water exchange, mineral nutrition, metabolism, growth, and development. During photosynthesis, plants utilize solar energy to synthesize organic compounds from inorganic substances, making this process a crucial step in both the cycling of matter and the flow of energy within the biosphere. Respiration, in turn, ensures the release of energy through the breakdown of organic compounds within plant cells. Furthermore, plant growth and development are regulated by phytohormones, environmental factors, and genetic determinants. The coordination of these processes is essential for the normal functioning of the plant organism.

In the context of higher education, studying plant physiology is of great importance for forming fundamental scientific knowledge among biology students. This course enables students to acquire systematic understanding of the functional structure of plants, the mechanisms of physiological processes, and their interactions with the external environment. In addition, it develops practical skills such as conducting laboratory experiments, observing biological processes, analyzing experimental results, and drawing scientific conclusions. As a result, students gain the competencies to explain biological phenomena scientifically, analyze complex problems, and conduct independent research.

Plant physiology is closely interconnected with other biological disciplines. Specifically, biochemistry deepens the theoretical foundations of plant physiology by studying chemical reactions and metabolic processes occurring in plant cells. Genetics plays a crucial role in explaining the hereditary traits of plants and the genetic regulation of physiological processes. Its link with ecology is evident in studying how plant organisms adapt to environmental factors. Moreover, plant physiology is strongly associated with modern scientific fields such as molecular biology, microbiology, and biotechnology. Consequently, this course plays a significant role in forming an integrated system of scientific knowledge in biology education [9;10].

Integrative education is a pedagogical concept aimed at creating organic connections between various disciplines, bodies of knowledge, and competencies, thereby shaping the learning process into a unified, systematic, and meaningful whole. It serves to strengthen students' personal development, foster skills for systematic understanding of the world, and facilitate comprehension of complex scientific knowledge [1]. The integrative approach ensures that, through effective understanding and application of interdisciplinary links, knowledge is acquired as a cohesive system rather than fragmented pieces [2].

Interdisciplinary integration refers to the principle of combining knowledge from different subjects and developing students' thinking based on generalized knowledge to solve complex social and scientific problems. The principles of integration ensure that all components of teaching content, didactic tools, and

the pedagogical process are interconnected, thus achieving a unified goal in the educational process [5]. At the same time, the integrative approach strengthens interdisciplinary connections, develops students' thinking, and enhances skills in harmonizing knowledge with practice, systematic reasoning, and problem-solving [3].

In higher education institutions, the integrative approach allows students to understand complex knowledge, synthesize concepts from various disciplines, and apply them in practical contexts [4]. Through this approach, students link theoretical knowledge with laboratory and experimental activities and learn to independently analyze complex problems. Integrative education also promotes creative thinking, professional competencies, and research potential, as it develops strategies for solving complex tasks based on interdisciplinary knowledge [1].

Pedagogical literature emphasizes that the integrative approach enriches the teaching process through the use of innovative pedagogical technologies and methods. This approach enables instructors to consider interdisciplinary links in lesson planning, reinforce integration throughout students' learning activities, and engage students in diverse modes of thinking [5].

Teaching the course "Plant Physiology" through an integrative approach enables students to combine knowledge from biology, biochemistry, genetics, ecology, and botany. This approach helps students understand complex physiological processes within a broader scientific context, identify interdisciplinary connections, and acquire skills for systematic knowledge assimilation. Thus, students analyze processes such as photosynthesis, respiration, or metabolism not only theoretically but also by linking them with concepts from other disciplines.

Theory-Practice Integration is a fundamental pedagogical principle in teaching "Plant Physiology." This approach allows students to test theoretical knowledge through laboratory experiments, field observations, and practical exercises. By applying the concepts in practice, students develop scientific thinking and learn to substantiate their conclusions. For example, explaining photosynthesis or respiration solely in theoretical terms may result in superficial understanding; however, laboratory experiments on leaf cells and plant tissues enable students to grasp the mechanisms in depth. Practical sessions also train students to conduct scientific observations, set experimental parameters, analyze results, and draw visual and logical conclusions.

Integrating theory and practice further develops students' systematic thinking, scientific methodology, and the ability to synthesize concepts from related disciplines. This method strengthens both theoretical understanding and practical skills, thereby enhancing students' scientific potential in "Plant Physiology."

Laboratory Exercises and Experimental Work are among the most effective tools for deepening students' understanding of plant physiology. Through experiments, students directly observe physiological processes in plant cells, collect and analyze data, and formulate scientific conclusions. In this way, theoretical knowledge is reinforced through practical experience, while students cultivate scientific reasoning and experimental skills. Laboratory activities also train students in independent research: planning experiments, formulating hypotheses based on theoretical models, systematically analyzing results, and presenting findings visually. This process encourages independent thinking, problem identification, and solving issues through scientific methods.

Problem-Based and Research-Oriented Learning actively engages students in creative thinking and scientific inquiry. Students integrate theoretical knowledge with laboratory and field research, analyze collected data, and draw scientific conclusions from experiments. This approach allows them to apply interdisciplinary knowledge in practice, develop systematic strategies for solving complex tasks, and enhance their research potential. Additionally, problem-based learning fosters collaborative skills, enabling students to work in teams, exchange ideas, and critically analyze results through scientific discussions. Consequently, students develop not only individual but also collective research competencies, forming a strong foundation for their future professional and research activities.

Table 1.

Integration of the "Plant Physiology" Course with Related Disciplines

Subject	Integration Content	Significance in the Educational Process
Botany	Studies plant morphology, anatomy, systematics, and life forms	Helps students understand the relationship between the structure and physiological functions of plant organs
Biology	Examines general laws related to plant structure, life activity, and biological characteristics	Develops systematic understanding of the connection between plant structure and function
Biochemistry	Investigates chemical reactions, enzyme activity, and metabolic processes in plant cells	Aids in understanding the molecular basis of photosynthesis, respiration, and metabolism
Genetics	Explores hereditary traits, genetic regulation mechanisms, and the genetic control of physiological processes	Enables analysis of plant growth, development, and adaptation from a genetic perspective
Ecology	Studies plant interactions with environmental factors and ecological adaptation processes	Fosters ecological thinking and environmentally conscious attitudes in students
Molecular Biology	Investigates gene expression, protein synthesis, and molecular-level processes in plant cells	Provides a deeper understanding of the molecular mechanisms underlying plant physiological processes
Biotechnology	Utilizes plant cells and tissues to develop new varieties and produce biological products	Expands opportunities to apply plant physiology knowledge in agriculture and industry

This table demonstrates how the course “Plant Physiology” is intrinsically connected with related disciplines. Each subject offers a unique perspective on studying various aspects of plant organisms, enabling students to develop systematic knowledge. Through this integrative approach, students gain a comprehensive understanding of plant morphology, physiology, genetics, and ecology while developing both practical and scientific skills. The table supports students in analyzing biological processes holistically, recognizing interdisciplinary connections, and applying knowledge using modern pedagogical methods.

An integrative approach positively influences the development of scientific thinking in the educational process, as it combines knowledge across disciplines and encourages students to analyze complex scientific concepts. Research indicates that pedagogical processes organized based on interdisciplinary integration deepen students’ understanding, enhance their scientific literacy, and improve their ability to comprehend the world systematically [5]. When teaching complex subjects such as biology, integrative methods not only provide theoretical knowledge but also actively engage students in scientific inquiry, reinforcing their analytical and scientific thinking skills.

Teaching based on an integrative approach strengthens students’ analytical thinking and research competencies. Studying multiple disciplines in conjunction allows students to analyze phenomena from multiple perspectives, link theoretical concepts with practical examples, and perform comprehensive analyses of learning objects. Such a pedagogical approach enables students to make independent decisions in problem-solving situations, engage in deep reasoning according to research methodologies, and work systematically using scientific methods [6]. International studies emphasize that an integrative approach enhances systematic and analytical thinking, guiding students toward creative and scientific inquiry.

Furthermore, an integrative approach creates new pedagogical opportunities for improving modern biology education. By combining interdisciplinary concepts, students acquire advanced analytical skills,

which help them understand complex biological processes. For instance, the STEAM approach integrates biology, chemistry, and technology, exposing students to new knowledge and developing a systematic approach to solving practical problems [7].

This, in turn, improves the quality of biology education and strengthens students' ability to conduct independent scientific research. Teaching through an integrative approach develops not only independent thinking but also innovative problem-solving skills and the ability to apply new knowledge in practice. This pedagogical strategy aligns with contemporary educational requirements and contributes to the development of 21st-century competencies in students [8].

Conclusion. The discipline of "Plant Physiology" serves as a fundamental scientific and didactic subject within the biology education system, providing students with the opportunity to gain a deep understanding of vital processes in plant organisms. Through this course, students study photosynthesis, respiration, metabolism, growth, and development, while also developing the skills to analyze biological mechanisms at the cellular and tissue levels. Therefore, the content of the course contributes not only to the acquisition of theoretical knowledge but also to the development of practical competencies.

Teaching based on an integrative approach ensures that students acquire knowledge in a systematic and interdisciplinary manner. This approach fosters scientific thinking, analytical and research competencies, and the integration of theoretical and practical knowledge, while laboratory and experimental activities enhance the effectiveness of the learning process. Additionally, problem-based and research-oriented pedagogical strategies cultivate independent thinking and research potential in students, preparing them for future scientific and professional activities.

Future research directions include further improvement of teaching "Plant Physiology" using a STEAM-based approach, deepening interdisciplinary integration, and implementing virtual laboratories and interactive simulation technologies. Such studies would strengthen students' scientific inquiry, advance biology education according to contemporary standards, and improve the quality of instruction.

REFERECES:

[1] Baratov F. Sh., Abdullayeva B. S. Integrativ yondashuv va ta'lim jarayonida fanlararo bog'liqlikni qo'llashning pedagogik asoslari // Educational Research in Universal Sciences. - 2023.

[2] Abdukarimxodjiyeva M. Fanlararo integratsiyaning uslubiy va didaktik asoslari // Qo'qon universiteti Xabarnomasi. - 2025.

[3] Mamajanov Sh. A. Fanlararo integratsiya tushunchasi va uning pedagogik mohiyati // New Modern Researchers: Modern Proposals and Solutions. - 2026.

[4] Urinova F. U., Shokirova M. J. Integrative approach in the educational process of higher educational institutions // Modern American Journal of Linguistics, Education, and Pedagogy. - 2025.

[5] Xo'jamberdiyeva M.N., Elamonova Sh. I. Ta'lim sifatini oshirishda integratsiyaning o'rni va ahamiyati // Ta'lim innovatsiyasi va integratsiyasi. - 2025.

[6] Mashraboy N., Botirova D. Analitik va tadqiqotchilik kompetensiyalarini rivojlantirishda fanlararo integratsiyaning pedagogik imkoniyatlari // Maktabgacha va maktab ta'limi jurnali. - 2025.

[7] Ibodova S., Karimov A., Tursunova L. STEAM yondashuvi orqali biologiya fanini takomillashtirish // PowerTech Journal. - 2024.

[8] Semant Journals. Integrative approaches in higher education and STEM teaching: international perspectives // American Journal of Education, Engineering and Science. - 2025.

[9] Ergashevich, R.U. (2024, January). Methodological principles of professional competence development of the future biology teacher. In International Scientific and Current Research Conferences (pp. 1-5).

[10] Raxmatov, U. (2024). Integrativ yonashuv asosida biologiyadan masala va mashqlar yechish fanini o'qitishning nazariy asoslari. News of UzMU journal, 1(1.2. 1), 178-181.