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ARTICLE

Application and Significance of Botanics and Subject Integration in Higher Education (on the Example of Root Morphological Structure, Types, and Functions)

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Abstract

This article provides information about the application of integration in the education system, pedagogical integration, its role, and significance. It highlights the role and practical importance of using an integrated approach in teaching the topic of the morphological structure, types, and functions of roots in botany. The article discusses the benefits of applying integrated methods and integrated tasks in explaining the topic.

Keywords: education, integration, pedagogy, botany, integrated lesson, integrated tasks, pressure, concentration, dissolution, water absorption, text, foreign language.

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1 Introduction

Education is a systematic process aimed at providing learners with deep theoretical knowledge, skills, and practical competencies, as well as developing their general and professional knowledge, abilities, and capacities. The development of education is directly related to the proper organization of the teaching process. Today, enriching education with modern digital technologies, innovations, and integrations is one of the pressing issues. In general, the ongoing progressive reforms in education are not lagging behind the transformations in other fields in terms of importance and practical significance. This is because the consistent continuation of reforms in the education system determines the future direction of pedagogy.

The process of subject integration at all levels of education demonstrates that effective teaching based on interdisciplinary connections, as well as the proper pedagogical and methodological organization of lessons, enhances educational effectiveness. The term "integration" comes from the Latin words "integratio", meaning restoration or completion, and "integer", meaning whole. The integration system in the learning process eliminates shortcomings in education and strengthens the connections and interrelations between subjects [2]. This approach is based on understanding the relationship between differentiation and integration.

The main goal of pedagogy is to integrate various subjects with similar objectives into a unified system while supporting teachers in effectively implementing integration in their teaching practices.

Integration also plays a significant role in teaching biological sciences. In our research, we propose applying an integrated approach to botany lessons to develop a broad worldview and solid knowledge among students. This approach aims to

enhance the understanding of subject topics through interdisciplinary methods [3].

2 Materials and methods

Integrated lessons help students develop a deep understanding of the topic. They enable students to form a broad scientific worldview and understand the fundamental goal of teaching natural sciences, which is to develop a holistic perception of the natural world. Conducting lessons using an integrated approach and reinforcing them with integrated tasks is highly effective. Below, we examine the role and practical significance of using an integrated approach in teaching the topic of root morphological structure, types, and functions.

The root is one of the primary axial organs of plants. Through roots, plants attach to the soil and absorb water and dissolved minerals. In some cases, roots store nutrients for vegetative reproduction, and certain compounds may also be synthesized within them. Additionally, roots of different plants can chemically influence one another.

In plant life, roots perform the following physiological and mechanical functions:

1. **Absorption of water and dissolved minerals from the soil.** This function is carried out by young parts of the root with primary structures, root hairs, and mycorrhizal associations.;
2. **Anchoring the plant in the soil.** This ensures mechanical stability. For example, pulling out a corn plant that has been growing for four months requires a force of approximately 130 kg.;
3. **Synthesis of nutrients**;
4. **Interaction with soil microorganisms**;
5. **Storage of nutrients**. Examples include carrot, beet, radish, turnip, etc.;
6. **Facilitating vegetative reproduction**.

2.1 Root Pressure

Root pressure is a term used to describe the osmotic pressure differences that occur within root system cells, leading to the movement of water and nutrients. The water concentration in root hairs is lower than in the surrounding soil. Due to this difference, osmotic pressure develops, which is referred to as root pressure.

Root pressure enables the uptake of water and minerals from the soil through absorption hairs. It is one of the factors that contribute to water movement in the xylem. When air humidity is high and transpiration is low, excess water entering the roots due to root pressure is released through hydathodes on the leaves. This process is called **guttation**, and it is typically observed in humid climates.

Root hairs absorb water and mineral elements from the soil. To transport these substances to the plant's vascular system and organs (leaves, flowers, stems, and fruits), root pressure pushes the water and nutrients upward through vascular pathways (such as sieve tubes).

After providing students with information about root structure and functions, interdisciplinary connections are introduced to deepen their understanding. Since one of the primary functions of roots is absorbing water and dissolved minerals and transporting them to the upper plant organs, integrating foundational concepts from **physics** (pressure, concentration, and dissolution) into the lesson is highly relevant.

2.2 Understanding Pressure (Integration of Botany and Physics)

Pressure is a physical quantity that expresses the intensity of forces acting perpendicularly on a surface. It is measured in Pascals (Pa) or N/cm². If the forces are evenly distributed over a surface, the pressure is calculated using the formula:

$$P = \frac{F}{S}$$

Where:

- **F** = Force acting on the surface
- **S** = Surface area

Concentration (from Latin *con* – together and *centrum* – center) refers to the accumulation of a substance in a specific location. In chemistry, concentration describes the amount of solute dissolved in a given mass or volume of solvent.

Dissolution is the process by which substances transition from a solid (crystalline) state to a liquid state under the influence of heat. The melting process depends on the melting temperature of a pure substance. During dissolution, the spatial arrangement of atoms in a solid's crystal lattice is disrupted, allowing for the movement of molecules.

2.3 Chemical Properties of Water (Integration of Botany and Chemistry)

Water (H_2O) is a colorless, odorless, tasteless, and transparent liquid. It covers about 71% of the Earth's surface ($\sim 1.460 \times 10^{15}$ kg). Most of Earth's water is found in oceans, seas, lakes, and rivers (95.6%), with smaller amounts in glaciers, underground reservoirs (1.6%), and the atmosphere (0.001%). Water is also present in living organisms.

Water is a universal solvent, capable of dissolving gases effectively. Due to its electrolytic properties, it dissolves many acids, bases, and salts. Water is itself a good solvent. The combination of hydrogen and oxygen to form water releases heat:

Water is a universal solvent, capable of dissolving gases effectively. Due to its electrolytic properties, it dissolves many acids, bases, and salts. Water is itself a good solvent. The combination of hydrogen and oxygen to form water releases heat:

$$2H_2 + O_2 \rightarrow 2H_2O$$

At temperatures up to **300°C**, this reaction occurs slowly, while at **550°C**, it results in an explosion.

Water is an exceptionally stable compound. Above **1000°C**, only a small percentage of water molecules dissociate into hydrogen and oxygen. At **2000°C**, the thermal dissociation rate reaches 1.8%, at **3092°C** it reaches 13%, and at **5000°C**, complete dissociation occurs. Water also decomposes under **ultraviolet radiation** (**photodissociation**) **or radioactive exposure** (**radiolysis**), forming free radicals and hydrogen peroxide.

Water is involved in various **combination and decomposition reactions** and plays a critical role in chemical processes. It has **anomalous properties**, such as high surface tension, low viscosity, and unusually high melting and boiling points. One of its most remarkable characteristics is **density anomaly**: at **4°C**, water is densest (1000 kg/m^3), but its density decreases at both higher and lower temperatures.

3 Results

To assess and reinforce students' understanding, the following integrated tasks are assigned:

Figure 1. Solving Problems Related to Root Hairs

(Integration of Botany, Mathematics, and Biology in Problem-Solving and Exercises) The number of root hairs in a 3 mm² area of the camelthorn (Alhagi) plant is 1.5 times greater than that of corn in the same area. If the total number of root hairs in a 3 mm² area of both camelthorn and corn together is 4494, what percentage of the root hairs in camelthorn has been lost?

Solution:

- Corn has 700 root hairs per 1 mm^2, so in a 3 mm^2 area, it has:

$$700 \times 3 = 2100 \text{ root hairs.}$$

- The camelthorn plant has 1.5 times more root hairs than corn, so in a 3 mm^2 area, it has:

$$2100 \times 1.5 = 3150 \text{ root hairs.}$$

- The total number of root hairs given in the problem is 4494.
- Since corn's root hairs are intact, we subtract its count from the total:

$$4494 - 2100 = 2394 \text{ root hairs in camelthorn.}$$

- Ideally, the camelthorn should have had 3150 root hairs, but it only has 2394, meaning that:

$$3150 - 2394 = 756 \text{ root hairs have been lost.}$$

Now, calculating the percentage of lost root hairs:

$$\frac{756}{3150} \times 100 = 24\%$$

Thus, 24% of the root hairs in the camelthorn plant have been lost.

Educational Benefits:

This type of problem helps students apply their botanical knowledge using mathematical methods in real-world scenarios. It enhances critical thinking, analytical reasoning, and problem-solving skills.

For future educators, this approach fosters creativity by encouraging them to develop similar problems that can reinforce students' understanding. Additionally, teachers can use such problems to motivate students by making lessons more interactive and engaging.

Moreover, this material can serve as an interesting supplementary resource during lessons, helping students see the interdisciplinary connections between biology, botany, and mathematics.

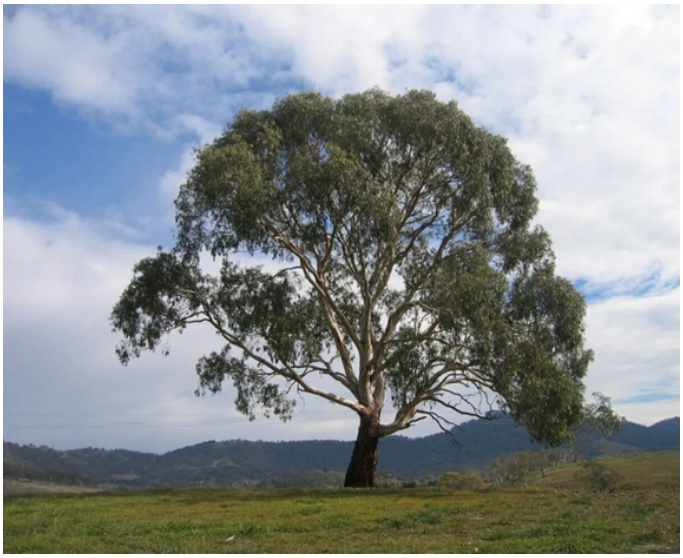

Figure 2. Eucalyptus and Baobab: Unique Water Absorption Features

Eucalyptus is humorously referred to as a "tree-pump" because its roots can absorb up to 300 liters of water per day. Due to this characteristic, it is often planted in swampy areas to drain excess water.

Baobab, on the other hand, has an even more fascinating ability. It stores large amounts of water in its trunk, causing it to appear swollen. During droughts, it drops its leaves to reduce water loss and relies on its internal water reserves. Once the rainy season begins, it absorbs water again and regrows its leaves.

In general, tree roots extend deep underground in search of water. Some trees' roots can reach several hundred meters deep to find moisture.

Next Activity: Integrating Botany and English Language Learning

Fill in the missing words. Use the word bank to help you.

The roots of a p _____ are very important. They help to a _____ the plant in the soil so that if the w _____ blows, the plant doesn't fall over. The r _____ also suck up w _____ and nutrients from the soil to help the plant g _____ and stay h _____.

Word Bank

Anchor, plants, water, grow, roots, water, healthy

By completing this task, students will learn key English vocabulary related to the topic. Studying scientific texts in a foreign language enhances their ability to access scientific databases and broadens their knowledge base. Simplified scientific texts like this help make language learning easier and more accessible.

This type (Table 1) of exercise strengthens students' understanding of botanical terms by connecting them to their definitions. It also enhances their ability to use scientific vocabulary correctly in both botany and foreign language studies.

Find the Errors in the Text

An Assignment Integrating Botany, Native Language, and Textual Analysis

The root is one of the most important generative organs of a plant. It anchors the plant in the soil, participates in photosynthesis, and stores nutrients. When the seed sprouts, an adventitious root develops. The totality of all roots in a plant is called the root system.

The root system can consist of a primary root and lateral roots, or it may only consist of a fibrous root system with no primary root. The root has a complex structure and is divided into several zones, each performing a specific function.

This exercise helps students develop skills in text analysis, scientific terminology, and error correction. Additionally, by reading the text carefully, they can identify spelling mistakes while improving their ability to work with scientific texts attentively.

Solve the Following Problems Independently

(Integration of Botany, Mathematics, and Biology in Problem-Solving)

Problem A:

Table 1. Survey Results on Environmental Education among Students and Educators

Terms	Definitions
Roots	D) The root that penetrates the deepest into the soil.
Root system	B) Underground organs of plants that absorb water and mineral salts and anchor the plant in the soil.
Primary root	E) The entire system of all roots in a plant
Lateral root	F) Roots that emerge from the sides of the stem.
Adventitious root	J) Roots that grow from the main root and spread sideways.
Taproot	C) A system composed of adventitious and lateral roots.
Fibrous root	A) A system consisting of a main root and lateral roots.

The total number of root hairs in 3 mm² of corn and an unknown plant is 3420. The difference in the number of root hairs in 2 mm² of these plants is 120. Find the percentage of corn's destroyed root hairs.

Problem B:

The total number of root hairs in 4 mm² of corn and hemp is 5850.

The sum of corn's destroyed root hairs and hemp's root hairs is 4950.

The number of corn's destroyed root hairs is 4.21 times less than hemp's root hairs.

Find the percentage of corn's destroyed root hairs.

Independent Work for Students

If the teacher has previously demonstrated methods for solving biological problems, students are now expected to work on slightly more complex problems independently. This assignment enhances their mathematical calculation skills, quick and critical thinking, and independent problem-solving abilities.

4 Discussion

Nowadays, special attention is being paid to the issue of integration in education. In their article, *"How to Organize an Integrated Lesson?"*, I. Kalozhvari and L. Pechnikova emphasize that the future of integration is bright. According to them, integration expands students' understanding of the world and enhances their ability to apply knowledge in practice. Through this approach, students learn faster and more effectively while gaining a clearer understanding of the connections between different subjects. Therefore, focusing on integration is essential for improving the effectiveness of lessons.

E. Smirnova, in her article *"Own Before You Possess"*, highlights the importance of integrating reading, writing, visual arts, and labor studies at the early stages of education. She argues that focusing solely on reading and writing may cause fatigue and negative emotions in students. To maintain students' interest in learning and enhance their engagement, an integrated approach is necessary.

According to M.N. Berulava, integration in the learning process helps students acquire systematic and long-lasting knowledge. Similarly, N.K. Chapayev states that the integration process is based on different approaches, ensuring interdisciplinary connections and contributing to the formation of a holistic education system.

Educational expert V.S. Bezrukova emphasizes the importance of integrating and differentiating knowledge in education. She believes that this process helps students develop a unified understanding of nature and society.

Psychologist E.N. Kabanova-Miller argues that a key sign of intellectual development is the ability to independently solve unfamiliar problems. Similarly, L.P. Elenko views integration as a tool for improving lesson effectiveness, stating that it elevates subject interconnections to a new level.

R.A. Mavlonova describes interdisciplinary integration as a method of replacing general education courses. For example, subjects such as reading, native language, natural science, and visual arts can be combined into an integrated curriculum.

The issue of interdisciplinary connections in education has been studied by many researchers. M.N. Skatkin identifies three main types of interdisciplinary relationships:

1. The connection between previously learned knowledge and newly acquired knowledge.
2. The connection between current knowledge and

future learning.

3. The relationship between different subjects being learned simultaneously.

Integration in Botany Education

Based on the above perspectives, it is crucial to highlight the advantages of applying integration in Botany education:

- Allows students to systematically and deeply study topics;
- Develops critical and logical thinking, enhancing adaptability;
- Strengthens interdisciplinary connections, making complex topics simpler and more understandable;
- Fosters creativity while increasing students' interest and motivation in learning;
- Enhances teaching efficiency, encouraging pedagogical expertise and creative approaches;
- Helps prepare socially and professionally competent specialists with a broad worldview

Overall, integration is a key method for improving learning effectiveness, strengthening students' knowledge, and increasing their engagement in the learning process. By connecting subjects, students gain a more comprehensive understanding of concepts, allowing them to apply their knowledge practically in various disciplines.

5 Literature review

This article is based on information about the structure, functions, and types of roots, taken from the **"Botany"** textbook authored by **H. Esanov** [5]. The preparation of problems related to roots was based on the **"Collection of Biology Problems"** by **B. Hakimov**. The role of interdisciplinary connections in improving the quality of education, expanding students' worldview through subject integration, and the benefits of integrated lessons were discussed [4]. The article by **G. Komiljonova**, titled **"Developing Students' Knowledge and Skills through Interdisciplinary Connections"**, was used to analyze the effective implementation of interdisciplinary connections in the educational process [1].

6 Conclusions

Thus, the application of integration in the educational process is a complex pedagogical issue that not only improves students' educational, developmental, and cognitive processes but also enhances their motivation and strengthens interdisciplinary connections. Taking these aspects into account, this article analyzes the theoretical foundations and practical significance of using integration in teaching **"Botany"** in higher education institutions.

Moreover, improving the professional preparation of future biology teachers, developing their pedagogical skills, creating effective innovative teaching methods, refining curricula, and enhancing students' academic and methodological activities remain urgent pedagogical tasks today.

The integration of subjects in teaching botany provides learners with an in-depth understanding of topics and the ability to apply theoretical knowledge in practice. In particular, the assignments presented above serve as resources for students to reinforce their theoretical knowledge. Assigning tasks related to multiple disciplines prevents monotony and helps maintain students' engagement and interest in learning.

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