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# THE USE OF AN INTEGRATIVE APPROACH IN TEACHING THE TOPIC OF GYMNOSPERMS IN HIGHER EDUCATION (BASED ON A PRACTICAL SESSION ON THE DIVISION OF GYMNOSPERMS OR CONIFERS)

**Keywords:** Integration, interdisciplinary connection, pedagogy, practical training, integrative tasks, integrative methods, conifers, resin, essential oil, medicine, vitamin C, antioxidant, thesis, pharmaceuticals, case study.

**Abstract:** This article examines the pedagogical effectiveness of an integrative approach in higher education using botany instruction as a case study. The study aims to substantiate the role of interdisciplinary integration in enhancing students' theoretical knowledge, practical skills, and professional competencies. A structured methodological framework for organizing practical training sessions on gymnosperms was developed based on integrative principles combining botany with chemistry, mathematics, physics, and medical sciences. The research employs qualitative pedagogical analysis and practice-oriented methods, including observation, comparative analysis, and reflective evaluation during practical sessions. The results indicate that the integrative approach significantly improves students' analytical thinking, interdisciplinary reasoning, and ability to apply biological knowledge in real-life and professional contexts.

The scientific novelty of this study lies in the development of a systematic integrative lesson algorithm specifically designed for higher education botany courses. The findings confirm that integrative teaching enhances the quality of professional training for future biology teachers and contributes to the formation of

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interdisciplinary competencies required in modern education. The proposed model can be effectively applied in higher education institutions to improve learning outcomes in natural science disciplines.

**Introduction:** Education is a systematic process aimed at developing learners' theoretical knowledge, practical skills, and professional competencies. The effectiveness of education largely depends on the organization of the teaching process and the use of modern pedagogical approaches. In recent years, the integration of disciplines has become one of the most important directions in educational reform, as it allows learners to form a holistic understanding of the world and apply knowledge in practice. In the context of global and national educational reforms, including strategies aimed at improving the quality of higher education and teacher training, interdisciplinary integration is regarded as a key pedagogical priority. Modern higher education institutions are expected to prepare specialists who possess not only subject-based knowledge but also interdisciplinary competencies, critical thinking, and problem-solving skills. Integration in pedagogy enables the establishment of meaningful connections between subjects, eliminates fragmentation of knowledge, and enhances learning efficiency. This approach is particularly relevant in teaching natural sciences, where phenomena are closely interconnected. Therefore, the application of an integrative approach in botany education is both timely and pedagogically significant.

From a pedagogical perspective, interdisciplinary integration is not merely a combination of subjects but a purposeful instructional strategy aimed at developing students' analytical abilities and professional competencies. In higher education, this approach allows future specialists to perceive scientific phenomena as interconnected systems rather than isolated concepts. The present study considers integration as a pedagogical condition that enhances the effectiveness of practical botany instruction.

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The purpose of this study is to analyze the pedagogical effectiveness of integrative teaching in higher education and to develop a methodological framework for organizing practical botany lessons based on interdisciplinary integration.This approach aims to enhance the understanding of subject topics through interdisciplinary methods.[1]

**Methods**

The study is based on qualitative pedagogical analysis and a practice-oriented research methodology. Integrative tasks were designed and implemented during practical botany sessions for undergraduate students. The instructional model combined botany with elements of chemistry, mathematics, physics, and medical sciences. The effectiveness of the integrative approach was assessed using observation, comparative analysis, and reflective evaluation of students' learning activities. Students' engagement, analytical thinking, and ability to apply interdisciplinary knowledge were analyzed throughout the practical training process.

The use of an integrative approach in education has proven to be highly effective. Specifically, in conducting practical sessions in the subject of botany, applying interdisciplinary integration to explain the essence of scientific phenomena contributes significantly to students' deep understanding of the topic and fosters broader scientific outlooks and cognitive development.

The lesson begins with a brief theoretical overview of Gymnosperms. The order *Pinales*, belonging to the family *Pinaceae*, comprises around 10 genera and approximately 250 species. This family consists mainly of evergreen, and partially deciduous, trees and occasionally prostrate shrubs. Their leaves are needle-like,

[1] K. Qayumova, M. (2025). Oliy o'quv yurtlarida botanika va fan integratsiyasining qo'llanilishi va ahamiyati (ildizning morfologik tuzilishi, turlari va vazifalari misolida). *J Ochiq , 1* (02), 1 7. https://doi.org/10.70728/jopen.be.0225.001

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scale-like, or linear-lanceolate in shape, varying in size. The leaves are perennial, typically persisting for 2 to 7 years.

Their cones are unisexual. The male cones bear microsporophylls, each containing two microsporangia (pollen sacs). The pollen is adapted for wind dispersal. Female cones contain ovuliferous scales, each bearing ovules on their surface. The seeds are winged and adapted for wind dispersal.

**Classification:**

- **Class:** Pinopsida – Conifers
- **Order:** Pinales – Pine-like
- **Family:** Pinaceae – Pine family
- **Representative species:** *Pinus sylvestris* – Scots pine

Scots pine (*Pinus sylvestris*) is cultivated in Uzbekistan as an ornamental plant. Its stem exhibits a eustele type anatomical structure, with open collateral vascular bundles arranged regularly. The wood consists primarily of tracheids. The bark, leaves, and wood tissues contain essential oils.



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The genus *Pinus* includes approximately 100 species. One notable species, the Eldar pine (*Pinus eldarica*), naturally found in Azerbaijan and Georgia, is widely cultivated in various cities across Uzbekistan due to its drought tolerance.

Among the most widespread species are *Pinus sylvestris* (Scots pine) and *Pinus sibirica* (Siberian pine). Scots pine has an extensive range, stretching from Central and Northern Europe to Northern Asia. It is ecologically versatile, thriving in mountainous regions, sandy soils, riverbanks, and marshlands. It is a light-demanding species, typically growing upright with a height ranging from 20 to 40 meters. The bark is reddish-brown, and the cones, found in pairs on shortened shoots, are bluish and persist on the branches for up to three years. Reproduction is through seeds, with most cones being dioecious, composed of either microsporophylls or megasporophylls.

This genus includes several regional species: the Siberian pine in Siberia, the European pine in the Carpathians and Alps, and the Caucasian pine in Crimea and the Western Caucasus. The timber of Scots pine is widely used in construction, furniture making, shipbuilding, railway carriages, and the aviation industry.

The buds and shoots of *Pinus sylvestris* contain essential oils, resins, bitter substances, tannins, vitamin C, carotene, anthocyanins, and other biologically active compounds. In medicine, the buds, needles, essential oils, and resins extracted from the stem are utilized for their therapeutic properties.

**Practical Session Algorithm for Studying Pine**

In the next stage of the lesson, students engage in a hands-on practical session using the following algorithm:

1. **Examine the herbarium specimens and cones** of pine. Observe the placement and color of male and female cones on the branches. Use a magnifying lens to inspect the structure of male cones, including the sporophylls and central axis.

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2. **Identify the structures beneath the sporophylls** and study their form. These include the microsporangia, which house the mother cells that undergo meiosis to produce tetrads of four cells. The tetrads develop into pollen grains (microspores). Each pollen grain has a double-layered wall: the outer exine and inner intine. The microspore begins to develop in the microsporangium and divides into four cells—two of which degenerate, while the remaining two become the vegetative and generative cells. The generative cell forms two male gametes (sperm cells), and the vegetative cell develops into the pollen tube.

3. **Observe the female cones under a magnifying lens**, focusing on the position and structure of the megasporophylls. Take one scale and examine it closely. Each megasporophyll typically bears two ovules (megasporangia) at its base, oriented toward the cone axis.

4. **Within the immature ovule**, the integument and nucellus can be distinguished. One of the cells in the nucellus differentiates into a megaspore mother cell, which undergoes meiosis to form four cells. Three of these degenerate, and one becomes the functional megaspore. This megaspore divides several times to form the female gametophyte, which contains two archegonia, each with an egg cell. One sperm enters the archegonium and fertilizes the egg cell, initiating the development of the embryo.

5. **After fertilization**, the zygote develops into an embryo and stores nutrients. The cone turns green and continues developing. By autumn, the cone turns brown, dries out, and releases seeds.

6. **Students are instructed to draw** the female cones and megasporophyll structures.

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To further elaborate on the topic, students are provided with theoretical information on **resins and essential oils**, covering their chemical properties, ecological functions, and uses in medicine and pharmacy.

**Information about Resins and Ethers**

**(Integration of Botany and Chemistry Disciplines)**

**Resin** is a high-molecular-weight organic compound. It is characterized by its amorphous nature, gradual softening upon heating, transformation into a viscous state when melted, ability to form films when dissolved in organic solvents, and insolubility in water. These are among the defining physical and chemical properties common to many types of resins.

Resins are categorized into **natural** and **synthetic** types. Natural resins include *rosin (colophony)*, *dammar*, *copal*, *sandarac*, *amber*, and *bitumen*. Historically, natural resins were widely used in the production of varnishes, adhesives, paper coatings, and phonograph records. However, in modern industrial applications, natural resins have largely been replaced by more promising **synthetic resins**.

Examples of synthetic resins include **phenol-formaldehyde**, **polyvinyl chloride (PVC)**, **carbolite**, **melamine-formaldehyde**, and **polyamides**. These resins are utilized in the production of **plastics, adhesives, synthetic fibers, films,**

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**varnishes, electrical insulation materials**, and **organic glass** (plexiglass), among others.

In **chemistry**, **ethers** are compounds derived from oxoacids in which at least one hydroxyl group (−OH) is replaced by an **alkoxy group (−O−)**. For example, during the esterification reaction between a carboxylic acid and an alcohol, esters are formed. **Glycerides**, which are esters of glycerol and fatty acids, are biologically important and form the primary class of **lipids**—the main components of **animal fats** and **plant oils**.

Ethers generally possess **pleasant aromas**, especially those of low molecular weight, and are commonly used as **fragrant compounds**. **Essential oils** often contain various ethers and are found in **pheromones** as well. Industrially, ethers serve as **high-quality solvents** for a wide range of applications, including **plastics, plasticizers, resins, and varnishes**.

Ethers also constitute one of the largest categories of synthetic lubricants in the commercial market. **Polyesters**, which are important plastics, are formed by linking monomer units through ester functional groups. In **molecular biology**, **phosphoesters** form the structural backbone of **DNA molecules**. Some nitrate esters, such as **nitroglycerin**, are well-known for their **explosive properties**.

**Results**

The implementation of integrative tasks during botany practical sessions demonstrated positive educational outcomes. Students showed increased interest in the subject, improved logical and analytical thinking, and a deeper understanding of interdisciplinary connections. The use of integrative assignments encouraged students to apply theoretical knowledge to practical and real-life situations. As a result, students were able to better understand the practical significance of botanical concepts Overall, the results confirm that interdisciplinary integration increases learning efficiency and supports the development of professional

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competencies necessary for future biology teachers.and their relevance to other scientific disciplines and professional activities.

To reinforce the knowledge acquired on the topic, several integration tasks are given to the students:

**1. Botanical Problems**

*(Task related to the integration of Botany and Mathematics)*

We will study a forest plot where pine trees are grown:

- 400 pine trees grow per hectare.
- The total area of the forest is 25 hectares.
- Each tree produces an average of 2.5 kg of resin per year.

**Questions:**

1. Calculate the total number of pine trees in the forest.

2. How much resin is produced annually?

3. If the market price of resin is $5 per kg, what is the total profit for this forest?

**The task is solved in the following steps:**

**Question 1: What is the total number of pine trees?**

If there are 400 trees per hectare, how many trees are there in 25 hectares?

**Calculation:**

400 trees × 25 hectares = 10,000 trees

**Answer:** 10,000 pine trees are grown in the forest.

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**Question 2: How much resin is produced annually?**

Each tree produces 2.5 kg of resin per year. Now, how much resin is produced by 10,000 trees?

**Calculation:**

10,000 trees × 2.5 kg = 25,000 kg of resin

**Answer:** 25,000 kg of resin are produced annually.

**Question 3: What is the market value of the resin?**

If the market price of resin is $5 per kg, how much revenue will the forest generate?

**Calculation:**

25,000 kg × 5 dollars = 125,000 dollars

**Answer:** The forest generates a profit of $125,000 from resin production annually.

This task requires students to apply botanical knowledge, logical thinking, and mathematical literacy. Let's break down the problem: 400 pine trees grow per hectare, and the total forest area is 25 hectares. Therefore, the student must use logical reasoning to solve the problem. The first part of the solution is to calculate the total number of pine trees in the forest. The next question addresses how much resin is produced by the trees, given that each tree produces 2.5 kg of resin annually. After performing the calculations, students will determine the total resin production for the entire forest. The final step requires students to research the average market price of resin to calculate the potential profit, highlighting the economic significance of pine trees.

Additionally, the economic importance of pine trees is emphasized, as they not only help purify the air by releasing **phytoncides**, but they also produce **resin**. Resin is used in the production of plastics, varnishes, adhesives, synthetic fibers, films, electrical insulation materials, organic glass, and other products.

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**2. Thesis: Extinct Species of Gymnosperms**

*(An assignment integrating Botany, Research Methodology, and History)*

In the process of completing this assignment, students will be required to refer to several recommended scientific sources, internet resources, and historical perspectives. They will study the periods in which gymnosperms emerged and declined, analyzing what life on Earth looked like during those times, including its climate and environment.

This helps students acquire not only biological knowledge but also historical insights. By learning about the flourishing periods of gymnosperms, they gain an understanding of the optimal climatic conditions for their growth, which also fosters their geographical knowledge. The reasons behind the decline of gymnosperms and the events or processes that led to their disappearance are revealed through historical facts.

To determine which gymnosperm species still exist today, where they can be found, and what environments they thrive in, students will need to turn to the science of ecology.

Clearly, assignments based on interdisciplinary integration help students understand the deeper essence of scientific phenomena and contribute to forming a holistic perception of the natural world. The assignment is expected to be presented in the form of a **thesis**. While working on this task, students will also learn how to structure a thesis and understand its specific features. This process contributes significantly to preparing them for future scientific research activities.

**3. What Do You Know About the Physical Properties of Pine Trees?**

*(An assignment integrating Botany and Physics)*

**1. How is the aerodynamics of pine needles achieved?**

Pine needles are narrow and cylindrical in shape, which reduces air resistance. This

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aerodynamic form helps protect the tree from wind stress and prevents excessive snow accumulation during winter, reducing the risk of limb breakage.

**2. How can the effects of wind and precipitation on coniferous trees be studied?**

By using meteorological instruments such as anemometers and hygrometers, researchers can measure needle movement, bending, and moisture retention. Through experiments and field observations, the impact of wind speed and precipitation on needle-bearing trees can be scientifically analyzed.

**3. How does the mechanism of water rising through the wood occur via the capillary effect?**

The xylem tissues in pine trees consist of tiny tubes. Water moves upward from roots to leaves through these tubes by the forces of cohesion and adhesion, forming capillary action. This mechanism becomes especially active in summer when transpiration rates increase.

By answering the above questions, students can uncover the physical phenomena observed in pine trees and gain an understanding of the real-world physics at play. As we know, natural sciences are interconnected. To fully comprehend natural processes, it is crucial to study them through an interdisciplinary approach. This fosters a deeper and more unified vision of the natural world.

**4. Pine Trees Release Various Substances: How Are These Used in Medicine and Pharmaceuticals?**

*(An interdisciplinary task integrating botany and medical sciences)*

Pine trees are not only important for maintaining ecological balance, but they also release a variety of biologically active substances that have significant medicinal and pharmaceutical value. These substances, due to their specific

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chemical composition, have been used in traditional and modern medicine for centuries.

| Extract from Pine | Botanical Source (Part) | Chemical Properties | Medical/Pharmaceutical Applications |
|---|---|---|---|
| Terpenes (α-pinene, β-pinene) | Essential oil (pine needles, branches) | Antiseptic, anti-inflammatory | Used in respiratory infections, as an expectorant |
| Pine resin (oleoresin) | Exudes from bark and branches | Sticky, bactericidal properties | Used in wound healing, ointments for joint pain |
| Pine oil | Obtained by distillation | Antibacterial, antifungal | Used in aromatherapy, skin diseases, and for rheumatism |
| Flavonoids (approximate) | Needles, bark | Antioxidant, anti-inflammatory | Dietary supplement for cardiovascular health |
| Vitamin C | Found in fresh needles | Boosts immunity | Used against scurvy, as a general tonic |
| Tannins | Bark, branches | Astringent properties | Used for oral infections and against diarrhea |
| Phytoncides | Emitted from the whole plant | Antimicrobial (kills microbes) | Used for air disinfection and viral disease prevention |

While completing the above task, students establish connections with the fields of botany, chemistry, pharmaceutics, and medicine. Furthermore, they gain the opportunity to explore not only the scientific study of plants but also their significance in human life and healthcare. This process motivates students to participate in new activities and research projects.

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## Discussion

The results of the present study confirm that integrative teaching creates a learning environment in which students actively construct knowledge through interdisciplinary connections. Unlike traditional approaches, this model encourages learners to analyze educational content from multiple scientific perspectives, thereby increasing cognitive engagement and independent thinking. Such an approach is particularly valuable in the professional preparation of future biology teachers.

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.

The novelty of this approach lies in its systematic application of interdisciplinary tasks specifically adapted for higher education botany courses. By linking theoretical knowledge with real-world applications, the integrative model enhances students' cognitive activity, independent thinking, and professional readiness.

Thus, the integrative approach serves not only as an effective teaching strategy but also as a tool for improving the quality of teacher education and preparing competitive specialists for modern educational systems.

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

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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.

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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.[2]

Here is the translation of the given paragraph into English:

**Conclusion**

Based on the findings of this research, it can be concluded that integrative teaching represents an effective pedagogical solution for modern higher education.

[2] [2] K. Qayumova, M. (2025). Oliy o'quv yurtlarida botanika va fan integratsiyasining qo'llanilishi va ahamiyati (ildizning morfologik tuzilishi, turlari va vazifalari misolida). *J Ochiq* , *1* (02), 1-7. https://doi.org/10.70728/jopen.be.0225.001

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The integration of botany with related disciplines enables students to apply theoretical knowledge in practical contexts, fostering professional readiness and interdisciplinary competence. The originality of the proposed model lies in its adaptability and relevance to contemporary teacher education.

As can be seen from the above, integrative lessons play a significant role in enhancing students' independent and critical thinking. The main goal of natural sciences is to form a holistic view of the world in the minds of learners, and integrative lessons are especially relevant in this regard. This is because studying life phenomena from physical, chemical, geographical, and even mathematical perspectives helps in understanding the core essence and meaning of the process. Moreover, integrative lessons are crucial in enhancing the skills of future biology teachers in applying independent, critical thinking, creativity, and innovative approaches in the classroom, which is an essential requirement of today's educational demands.

Furthermore, the integrative approach improves the professional training of future biology teachers by developing creativity, analytical skills, and interdisciplinary competencies. The proposed integrative lesson model can be adapted and applied in other natural science disciplines within higher education, contributing to improved educational quality and learning outcomes.

**Declarations for Main Manuscript File**

**Availability of Data and Materials**

All data generated or analyzed during this study are included in this published article.

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