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CREATIVE TEACHING METHODS FOR THE SUBJECT «MATERIALS SCIENCE» IN HIGER EDUCATION INSTITUTIONS

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Abstract. The article discusses creative approaches to teaching the "Material Science" course in technical higher educational institutions. It focuses on how modern educators creatively explain each topic of the course, addressing issues such as cultural awareness, ethics, and their own teaching mastery.
Keywords: Material Science, creativity, creative pedagogy, innovation.

Many scholars in their time and era have demonstrated their creativity and shared their views on creative teaching. For example, by looking through historical manuscripts, we can see that creativity existed even in ancient times. Without creative thinking in those periods, humanity would not have discovered fire by striking stones together, Thomas Edison might not have invented the electric bulb, and Leonardo da Vinci might not have gifted the parachute to mankind.

One of the directors of Harvard Business School, Professor T. Amabile, in her book *"Creativity: How to Unleash Your Potential"*, points out that:"Creativity consists of a number of factors, requiring experience, talent, original thinking, focus, and the ability to overcome habitual barriers."

Creativity reveals the innate qualities of an individual — their clarity of mind, sharp intellect, and ability to take action. It also plays a role as a tool that reflects how knowledgeable a teacher is.

According to American psychologist P. Torrance, creativity involves setting scientific or problem-oriented goals, testing and revising perspectives, forming solutions, and identifying contradictions in actions when resolving problems.

Currently, research on the development of individual creativity is expanding rapidly. This is because social experience recognizes that creative thinking is not only a personal trait but has social significance, pushing psychological and pedagogical thought to focus more on this issue.

The main task of the psychology of creativity is to explore creative methods and the psychological mechanisms of creativity. The development mechanisms of creative thinking have been examined by scholars such as Ya.A. Ponomarev, A.M. Matyushkin, and others. Researchers like S.M. Bernstein and O.K. Tikhomirov linked it to the system of thinking.

Studies in the psychology of creativity and its definitions have been carried out by foreign scholars such as J. Guilford, S. Mednick, K. Taylor, and E. Torrance.

Additionally, many researchers focus on individual traits or qualities when defining creativity. J. Guilford believes that creativity and the potential for innovation can be defined through a set of cognitive abilities and characteristics that influence successful creative thinking.

According to E.P. Torrance, creative abilities include the following sequence:

high sensitivity to problems, the need for knowledge, or contradictions;

actions aimed at identifying these problems and searching for their solutions based on hypotheses and assumptions;

activities related to solving problems and shaping the outcomes of decisions [1; p.22].

Like any other trait, creativity does not develop instantly. It is learned and formed in distinct stages, gradually evolving and developing based on evidence and experience. A teacher's

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possession of creative qualities is driven by their personal abilities, natural disposition, social engagement, and professional development, which all progress in connection with their pedagogical experience.

For educators working in the higher education system, possessing creative traits helps them to organize the educational and upbringing process differently from traditional teaching methods. It enables the creation of new ideas, encourages non-standard thinking, individuality, initiative, and tolerance for ambiguity.

A creative teacher is devoted to their profession with an inventive spirit. They actively generate new and advanced ideas that support the development of students' learning engagement and the quality of their individual learning. Such a teacher also independently studies previous pedagogical achievements and experiences, exchanges insights with colleagues, and shares best practices — all of which contribute to professional growth.

A teacher does not automatically become a creative individual. Their creative ability is formed through actively learning, self-development, and accumulated experience over a certain period of time. Just like in any profession, the foundation of creativity in future teachers should be laid during their student years. In organizing their own creative activity, it is important that teachers focus on solving problems, studying problematic situations, and developing educational tools and technologies with pedagogical characteristics.

In the field of pedagogy, the changes in the approach to creativity began in the 1960s and 70s. Gradually, a new wave emerged—educators who worked creatively. Their innovative teaching systems developed, and new methods became widely known. The novelty and effectiveness of their results attracted not only teachers but also psychologists who began to explore the psychological aspects of creativity in education and the mechanisms of creative activity in pedagogical psychology (e.g., V.V. Davydov, I.A. Zimnyaya, N.V. Kuzmina, Ya.A. Ponomarev, A.M. Matyushkin, Feldstein, and others).

Research into creativity, using various experimental models and distinctions, offers possibilities for practical application in professional andragogy.

Creativity is a valuable personal knowledge category and an integral part of an individual's **spiritual and creative development**. Creativity is not defined merely by the versatility of a person's knowledge, but by their **perception, responsiveness to problems, and openness to new ideas**. It is revealed in the ability to break persistent stereotypes and find unexpected and simple solutions to real-life problems, all for the sake of innovation.

In pedagogy, research into **creative thinking** as an individual category helps identify creative educational traditions, innovations, and management forms aimed at the personal development of learners through teaching and upbringing. The implementation of scientific research in practical aspects is reflected in experience-rich innovations and in modeling traditional educational and upbringing systems that are content-oriented.

As **students' creative thinking and behavior** evolve through intellectual activities, the learning process should create **psychological and pedagogical conditions** for individuals to access and develop their creative potential. Human creative abilities develop throughout life, but they may change depending on the **reassessment of life challenges** and the **reorientation of individual consciousness**.

Psychologists have identified that **creative thinking possesses specific characteristics**, such as the rejection of stereotypical behavior and the ability to detect **new and unique properties** of objects and the relationships between them. To achieve this, a person needs both prior experience in problem-solving methods and the capacity to reconstruct that experience in new, problem-based contexts.

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The level of creative thinking development can be measured by the following indicators:
Originality of thought: the ability to generate responses that differ from conventional answers (solutions that are rare or unique).
Recalling contradictions from past experience.
Non-standard and alternative thinking and perception.
Unexpected activation during the resolution of professional problem situations.
Quick and diverse associative connections: the ability to find unusual links between different objects.
Sensitivity to problems: the capacity to identify contradictions in changing phenomena, discover new problems, and connect them with existing ones.
Immersion into the problem while simultaneously distancing oneself from the present moment and imagining the future.
Fluency of thought, reflected in the number and variety of similar ideas generated within a given time frame.
The ability to identify multiple unconventional uses for an object or its parts.
Discovery and analysis of new ideas, questioning seemingly obvious thoughts, and moving beyond superficial analysis.
Flexibility and diversity in correct decision-making.
Self-selection and reflection, including the ability to analyze one's own behavior, and an increase in disproportionate but targeted opinions to solve specific problems.
Maturity and clarity of decisions.
The **development of creative thinking in individuals** often combines deep knowledge, diverse abilities, educational competencies, and **a personal style** that manifests consistently in their worldview, behavior, and actions.
Students' thinking is stimulated through questioning.A teacher's question must make the student think and, at the same time, allow them to find an answer independently.
To encourage learners' creative engagement in the learning process, a teacher's pedagogical toolkit should include methods of **questioning** that meet the following criteria:
Conciseness: The question should be brief and clearly understood.
Neutrality: The question should not cause difficulty or confusion, nor should it imply a specific correct answer.
Clarity: The content of the question must be easily perceived and understood by the respondent.
Openness: The question should be based on prior knowledge and presented in a way that is easy to comprehend.
Timing: A positive classroom atmosphere should allow learners to express themselves freely, encouraging them to ask questions and engage in interaction. Learning situations, questions, and discussions should be structured.
This kind of pedagogical method is particularly effective when students are aware that **their participation is valued**. Therefore, enhancing **communication culture** is a key guarantee of the success of pedagogical methods.
The ability to listen to others and compare different viewpoints gives students a chance to present themselves positively and **develop their creative activity** during discussions.The formation and confrontation of opinions becomes a **tool for testing and refining creative thinking**.
To successfully manage the process of developing, educating, and shaping students, a **teacher must possess a deep understanding** of their subject and its methodology according to **modern scientific standards**.

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The teacher must also:
Be well-versed in **folk pedagogy, national pedagogy, psychology**, and other related disciplines.
Consider students' **age, individual characteristics, level of development, knowledge, and upbringing**, and adapt instruction accordingly — whether in groups, communities, or individually — and apply it appropriately, purposefully, and at the right time.
Be a true **moral role model** for students — demonstrating **spirituality, integrity, broad knowledge, cultural awareness, principle, honesty, and fairness**, not just in work, but in life.
Have **deep knowledge**, be **skilled**, and able to **effectively teach** learners in a hands-on way.
Strive to become a teacher **worthy of public respect** and **student trust**.
A teacher must possess:
Pedagogical ethics, attentiveness, and mastery in all aspects.To achieve this, they must work systematically on developing their own pedagogical intuition, attentiveness, and **natural teaching talent** to a professional level.
Mastery of pedagogical techniques, eagerness to learn and apply best practices and **modern national pedagogical technologies**, be familiar with **global teaching methods**, and be capable of thinking and working **independently and creatively**.
They must be **demanding**, **curious**, and **open to innovation**.

It is essential for a teacher to sincerely care for their profession and students, to be deeply committed to their students' future, and to genuinely trust them. These qualities inspire the teacher to undertake great new tasks and encourage students to justify their trust in their mentor.

The pedagogical process is a process built on the joint creative activity of the teacher and the students. Continuous searching, researching, learning, and creating are remarkable professional qualities of the teacher, and developing these qualities in students is a modern requirement. Therefore, a teacher must be not only an instructor but also a creative person. It is important not to forget that the teacher's creative competence and the students' creative competence develop simultaneously. [2; pp. 43-46]

In higher education institutions with a technical focus, a teacher of the "Materials Science" course must be a well-rounded educator, knowledgeable about the historical development of the subject as well as current relevant technologies and technical equipment. Along with explaining each topic to students, the teacher should rely on their own years of experience, pedagogical opinions and advice received from colleagues, and use modern innovative technologies to creatively convey the main goals of the topic to the students.

The teacher should not simply explain the content from textbooks but also utilize innovative materials available on current internet resources. If possible, organizing visits to nearby factories or production facilities to demonstrate in practice what has been taught would be very effective.

Here, as noted by Mihaly Csikszentmihalyi, a Hungarian-American psychologist and author of several pedagogical and psychological books, including *Creativity: Flow and the Psychology of Discovery and Invention* (1996), the teacher should demonstrate a creative-innovative approach to every topic based on creative processes.

"Creative" and "innovation" are two distinct but closely related concepts. There are significant differences in their meanings.

Creativity is the ability to generate new ideas and solutions. It is a creative process involving introducing innovations and breaking away from traditional methods. Creativity relates to thinking, understanding, and inventing new things, linked to cognitive abilities.

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Innovation is the practical application of a new idea or method. That is, innovation involves creating and implementing new technologies, products, services, or processes. The main goal of innovation is to improve life, increase efficiency, and strengthen competitiveness.

Simply put, creativity is about coming up with new ideas, while innovation is about putting those ideas into practice.

When teaching the "Materials Science" course, the teacher should pay attention to several important aspects:

1. Theoretical Foundations of Materials

Understanding fundamental concepts: It is necessary to clearly explain to students the structure, properties, types, and classification of materials, as well as how they respond to various external influences.Connection between theory and practice: The educator should demonstrate how the theoretical knowledge of materials can be applied in production and scientific processes. This helps students see the practical significance of the material being taught.

2. Classification of Materials

The educator should explain the classification of materials based on their chemical composition, structure, and properties, clearly showing the distinctive features and applications of each type of material.

3. Properties of Materials Mechanical properties: The educator should pay attention to important characteristics such as strength, plasticity, hardness, elasticity, and ductility of materials.Physical-chemical and thermal properties: Students should understand how factors like temperature, humidity, and chemical effects influence the forms of materials.Wear resistance and long-term durability: It is necessary to explain how materials change when used for a long time.

4. Methods of Testing and Selecting Materials The educator should teach students methods for testing material properties, such as strength, hardness, and impact resistance. Using the necessary tools and equipment for applying these methods is also important.

5. Modern Technologies and Innovations Attention should be given to recent advancements in materials science, such as nanomaterials, new production and processing methods, and the application of new materials in various fields (aviation, medicine, energy, etc.).

6. Environmental and Economic Aspects It is important to explain the selection of materials considering ecological factors and resource conservation, as well as the use of sustainable and environmentally friendly technologies in production.

7. Interactivity and Student Engagement The educator should employ various teaching methods such as demonstrations, laboratory work, research projects, and excursions to production sites or laboratories. This approach encourages students to engage actively and work practically with materials rather than just listening to lectures.

8. Connection with Other Subjects It is important to show that materials science is related to other scientific disciplines such as physics, chemistry, mechanics, engineering, and economics. This helps students understand the interdisciplinary nature of the subject.

9. Working with Scientific Literature The educator should teach students how to work with scientific articles, definitions, and demonstrations related to materials science. This enables students to stay updated with the latest developments and continuously renew their knowledge in the field.

10. Evaluation and Feedback Conducting regular tests and monitoring activities is essential for the consistent assessment of material comprehension. Additionally, motivating students and encouraging independent work helps improve learning outcomes.

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The "Materials Science" course is important for the development of engineering and scientific knowledge; therefore, the educator should integrate teaching theory, practical activities, and methods connected with actual production processes.

When teaching the "Materials Science" course at higher education institutions, attention should be paid to several important aspects to equally develop students' theoretical and practical knowledge:

Explaining Fundamental Principles and Concepts: Explain the structure of materials, their properties, and interrelationships.Clarify the fundamental properties, applications, and distinctions of various materials such as metals, polymers, ceramics, and composites.Explain the levels of composition (atomic, microstructural, macrostructural) and how they affect the properties of materials.

Experimental Work and Laboratory Practices: Provide students with opportunities to conduct laboratory work and experiments. This is important for verifying theoretical knowledge by observing the physical and mechanical properties of materials.Teach students to conduct material tests and understand testing methods.

Solving Applied Problems: Relate theoretical foundations of materials science to specific industrial and engineering problems.Allow students to choose appropriate materials for specific production situations, such as selecting materials for a particular structure or machine manufacturing.

Studying Material Integrity and Failure: Explain changes that materials undergo during long-term use, including fatigue, corrosion, fractures, and other mechanical failures.Teach methods used to increase the service life of materials, such as lubrication, thermal treatment, and chemical treatment.

Innovations and New Materials: Introduce students to modern materials and technologies, such as nanomaterials, smart materials, environmentally friendly, and recyclable materials.Familiarize students with current scientific research and emerging trends in the field.

Integration of the Subject and Connections with Other Disciplines: Explain that materials science is closely related to other subjects such as chemistry, physics, engineering, and mechanics.Students should understand the interrelations of these subjects and how they are applied within materials science.

7. Demonstrating the Practical Importance of the Subject: Clearly show the role and significance of materials science in various industrial fields through concrete examples. For instance, the use of materials in construction, aviation, automobile manufacturing, microelectronics, and energy sectors.

8. Teaching Students to Think Critically and Conduct Meaningful Research: Teach students research methods, how to select literature, and develop their own opinions.Expand students' horizons through discussions and group work.Based on these principles, the materials science course should aim to develop students not only in theoretical knowledge but also in practical skills and experiences.

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