



Technology for Directing Physics Lectures Towards the Development of Creative Thinking

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Abstract: Developing creative thinking is one of the key goals of modern education, especially in preparing future science teachers. Creative thinking enables learners to approach problems from new perspectives, generate original ideas, and establish meaningful connections between concepts. This article explores the importance of fostering creative thinking in physics education through innovative teaching technologies.

Specifically, the article focuses on the integration of creative thinking development strategies into lecture-based instruction in physics. It argues that lecture sessions, often considered passive, can be transformed into active and intellectually stimulating experiences through the use of visual simulations, interactive models, and problem-based tasks.

The article presents a practical application of this approach through the topic “Heat transfer in gases”. A sample lesson design is provided that includes 2D/3D visual simulations, conceptual explanations, and creativity-oriented teaching methods. The model demonstrates how physics lectures can be structured to stimulate students' imagination, foster associative and divergent thinking, and support systematic analysis—all core components of creative thinking.

This work contributes to the growing field of creativity-oriented STEM education and provides a model that can be adapted by educators seeking to modernize their physics instruction and enhance students' cognitive development.

Keywords: Creative thinking, Physics education, Instructional technology, Lecture-based learning, Heat transfer in gases, Simulation-based teaching, Teacher training, STEM methodology, Divergent thinking,

Visualization in science.

Introduction: In the modern educational landscape, the concept of creativity has gained significant attention as a core component of 21st-century skills. Creativity is generally defined as the ability to generate new, original, and valuable ideas. It is not limited to artistic expression but extends to all domains of knowledge, including science and education. One of the key cognitive processes underlying creativity is creative thinking. Creative thinking refers to the ability to think in novel and flexible ways, make unusual connections, approach problems from different perspectives, and produce multiple solutions. It encompasses essential mental skills such as imagination, association, recombination, transformation, generalization, and divergent thinking. Developing creative thinking in future teachers is especially important, as they will shape the mindset and learning strategies of the next generation. In physics education, where abstract concepts and complex systems are often difficult to visualize or relate to real-world contexts, creative thinking plays a crucial role in deepening conceptual understanding and encouraging problem-solving abilities. One of the most effective ways to foster creative thinking in pre-service physics teachers is through the use of virtual educational tools, such as simulations, animations, and interactive models. These tools allow learners to visualize invisible phenomena, manipulate variables, and experiment in a risk-free environment—thus activating the components of creative thought.

This article introduces a model technology designed to enhance creative thinking during physics lectures. The model is demonstrated through a sample lesson on the topic “Heat transfer in gases”, where visual simulations, targeted instructional methods, and creativity-oriented tasks are integrated to transform traditional lectures into dynamic, thinking-centered learning experiences.

Literature Review

Creative thinking has increasingly been recognized as a crucial skill in modern education, particularly in science disciplines such as physics. Dewi et al [2] emphasized that STEM-based guided inquiry in physics classrooms supports the development of students' creative skills. Similarly, Said et al [8]. found a positive correlation between students' creative thinking abilities and their academic performance in physics.

Maharani et al [5]. developed interactive physics learning media integrated with creative and critical thinking models, reporting that such integration

improved student outcomes. Fortunato Ribeiro [3] conducted an integrative review and concluded that teaching strategies that challenge students to analyze, create, and evaluate physical phenomena are key to fostering creative thinking.

In terms of teaching strategies, Lin [4] discussed methods specifically tailored for middle school physics education, such as open-ended questions, problem-based learning, and visual simulations, which have shown to stimulate creative engagement among learners.

Moreover, computational tools and simulations are increasingly used to build creative environments in physics learning. Odden and Caballero [7] introduced computational essays as a means to support deeper conceptual understanding, while Brahmia et al [1]. highlighted that mathematization in physics, though challenging, is essential for higher-order thinking.

Newton et al [6]. underlined the need for creativity in higher education physics teaching, arguing that creativity is not an add-on but a fundamental aspect of understanding and applying scientific knowledge.

These studies collectively affirm that integrating creative thinking strategies and virtual simulations into physics instruction significantly enhances learners' conceptual understanding and innovation skills. This article builds upon this foundation by proposing a specific instructional technology aimed at developing creative thinking through lecture-based physics topics, exemplified by the “Heat transfer in gases” lesson.

METHODOLOGY

This study adopts a practice-based qualitative research approach to explore the effectiveness of technology-integrated instruction in developing creative thinking skills among future physics teachers. The research was conducted in a higher education context, specifically involving students enrolled in a bachelor's program for prospective physics educators.

The participants of the study were undergraduate students majoring in physics education at a university in Uzbekistan. These pre-service teachers were selected due to their direct engagement with both theoretical and practical components of teaching physics.

The designed instructional technology was implemented during lecture and practical sessions, allowing flexible integration into various forms of teaching. The chosen topic for instructional modeling was “Heat transfer in gases”, a subtopic within thermodynamics, considered suitable for enhancing creative thinking due to its conceptual complexity and applicability.

The teacher should familiarize students with theoretical

knowledge about heat transfer in gases. For example: In gases, the heat conduction process occurs through the movement of molecules. The fast-moving molecules in a high-temperature region collide with the slower molecules in a lower-temperature region, exchanging energy. This phenomenon is called molecular heat conduction.

lower than that of solids and liquids, because the distance between their particles is large, making energy transfer less efficient.

When two gases are placed side by side, the rate of heat transfer between them. The rate of heat transfer between two gases is determined based on Fourier's law:

The thermal conductivity of gases is generally much

$$Q = -k \cdot A \cdot \frac{\Delta T}{\Delta x}$$

Where:

Q — heat flux density (W/m²),

k — thermal conductivity of the gas (W/m·K),

A —surface area (m²),

$\frac{\Delta T}{\Delta x}$ — temperature gradient, i.e., the change in temperature with respect to distance.

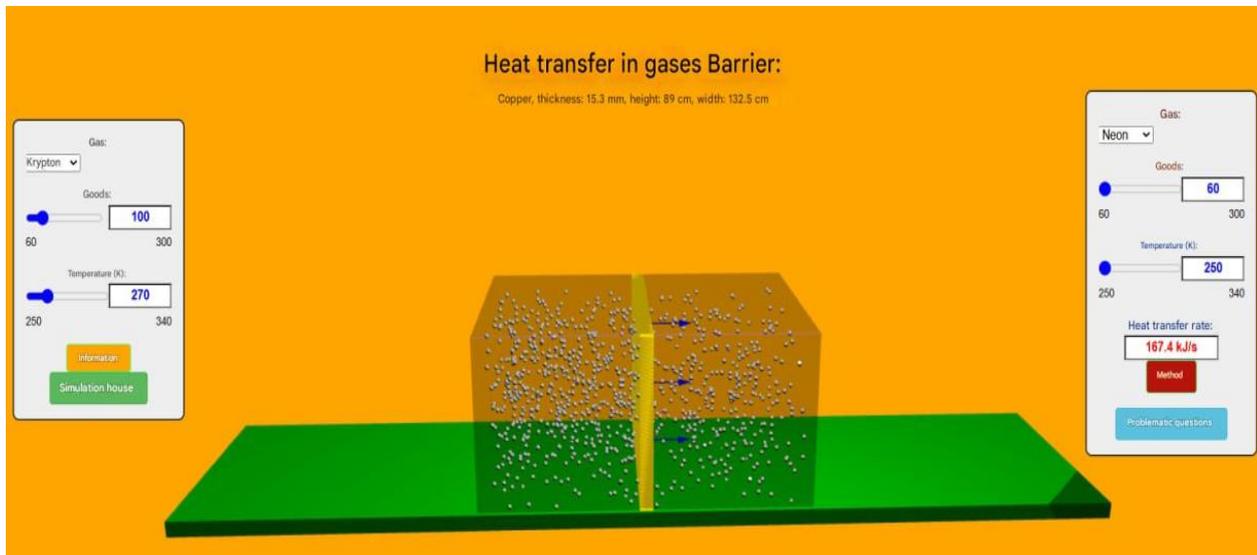


Figure 2. Virtual development for studying heat transfer in gases

A custom-developed 2D virtual simulation was employed to model thermal conductivity between two gas samples with modifiable parameters such as gas type, amount of substance, and temperature. The

simulation displayed the rate of heat transfer based on these variables, providing an interactive and dynamic learning environment.

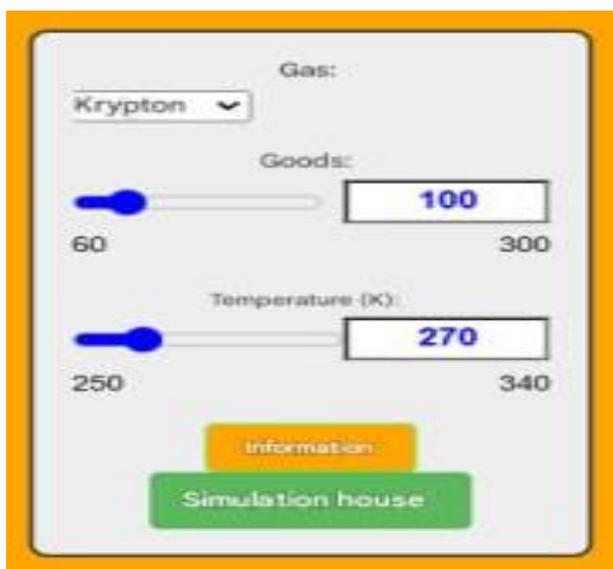


Figure 3. Buttons of a virtual development for studying heat transfer in gases (left side)

This section contains buttons for changing the type, amount, and temperature of the first gas, and when these parameters are changed, it is possible to observe how the behavior in the simulation changes. For example, the dependence of gas temperature on

velocity. Using the external sub-buttons, you can also obtain information on the topic of heat transfer in gases.

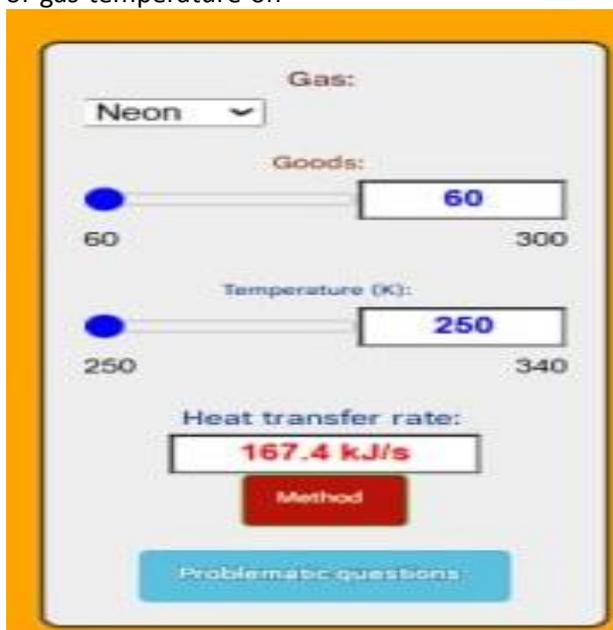


Figure 4. Buttons of a virtual development for studying heat transfer in gases (right side)

In this section, you can change the type of the second gas and its parameters, such as the amount of substance, temperature, etc. Changing these parameters also affects the behavior in the simulation, and each change will lead to a change in the numerical value of the heat transfer rate between the two gases. At the bottom of this section, there is a button for the

recommended method and a button for problematic questions on the topic of heat transfer in gases.

The simulation included:

A “Method” button, which suggested a recommended instructional method—in this case, the SCAMPER method—to guide creative thinking during lesson delivery.

A “Problem Questions” button, offering challenging, open-ended questions related to the topic to stimulate critical discussion and inquiry.

SCAMPER Method in Action

The SCAMPER method (Substitute, Combine, Adapt, Modify, Put to another use, Eliminate, Reverse) was utilized as a cognitive tool for engaging students in exploring alternative explanations and applications of thermal conductivity principles. For instance:

Substitute: What happens if we replace helium with carbon dioxide under the same conditions?

Combine: Can we observe the result when combining hot and cold gases?

Adapt: How does this phenomenon apply to real-life systems like air conditioning?

And so on, prompting students to think beyond the textbook definitions.

Assessment of Creative Thinking: To evaluate the

development of creative thinking, a combination of pre- and post-tests, reflective journals, and classroom observations were used. These tools were designed to assess the following dimensions of creative thinking: fluency, originality, elaboration, flexibility, and critical evaluation—based on Torrance’s creativity model. Instructors used a rubric to rate students’ responses and solutions in alignment with these dimensions.

RESULTS

The implementation of a virtual simulation tool integrated with the SCAMPER method was evaluated in a physics lecture on thermal conductivity in gases. The participants were 48 second-year students enrolled in a physics teacher training program.

A pre-test and post-test were administered to assess changes in students’ creative thinking skills. The test measured four components of creativity: fluency, flexibility, originality, and elaboration. The results are summarized in Table 1.

Table 1. Pre-test and Post-test Average Scores (5-point scale)

Component	Pre-Test	Post-Test	Difference
Fluency	2.6	4.1	+1.5
Flexibility	2.4	3.9	+1.5
Originality	2.1	3.7	+1.6
Elaboration	2.8	4.0	+1.2

In addition to the test, observational checklists were used during the class sessions to track engagement and participation. It was noted that over 85% of the students actively interacted with the simulation, posed creative questions, and proposed their own scenarios using SCAMPER.

Furthermore, reflective journals submitted by students after the session revealed a heightened interest in applying innovative methods in future teaching practice. More than 90% of participants agreed that the virtual simulation made the abstract concept of thermal conductivity more understandable and sparked curiosity.

DISCUSSION

The findings of this study suggest that the integration of virtual simulation tools with creative thinking strategies, particularly the SCAMPER method, significantly enhances the development of creative thinking among future physics teachers. The observed improvements across all four components of creativity—fluency, flexibility, originality, and

elaboration—are consistent with previous research (Torrance, 1974; Runco and Acar, 2012) that emphasizes the importance of active engagement and open-ended problem-solving in cultivating creativity.

These results align with studies by Mishra, Koehler (2006) and Voogt et al. (2015), which highlight that technology-enhanced learning environments foster innovative thinking when combined with pedagogical strategies that challenge students to analyze, adapt, and invent.

In the context of teaching thermal conductivity in gases, the virtual simulation served not only as a visualization tool but also as a platform for experimentation and hypothesis generation. Students’ ability to manipulate variables and immediately observe outcomes mirrors real scientific inquiry, thus strengthening both their conceptual understanding and creative confidence.

The SCAMPER method, embedded in the simulation, encouraged students to reinterpret standard knowledge through alternative perspectives—e.g., substituting variables, combining gas types, or

modifying quantities. This approach fostered divergent thinking and deeper exploration, which are essential in teacher education.

Moreover, the high levels of engagement and reflective feedback indicate that virtual tools—when properly scaffolded—can motivate learners to take intellectual risks and think beyond conventional methods. This supports the view of Sternberg, Lubart (1995), who argue that creativity in education emerges when learners are given the freedom and structure to explore novel ideas within relevant contexts.

Overall, the study demonstrates that creatively designed virtual resources can play a pivotal role in modernizing physics education and preparing future teachers to nurture creativity in their own classrooms.

CONCLUSION

This study has demonstrated that creative thinking can be effectively cultivated in future physics teachers through the integration of virtual simulations and structured instructional strategies such as the SCAMPER method. By using a specially designed 2D digital resource in the context of teaching thermal conductivity in gases, students were encouraged to explore, question, and innovate—hallmarks of creative cognition.

The use of interactive simulations allowed learners to visualize abstract physical concepts and engage in exploratory learning, while the embedded SCAMPER approach guided them in generating novel solutions and interpretations. As a result, all four components of creative thinking—fluency, flexibility, originality, and elaboration—showed marked improvement.

The findings underscore the need for teacher education programs to incorporate creativity-focused technologies and pedagogical methods, especially in subjects like physics where conceptual abstraction is high. Further research could expand this approach to other physics topics and explore its long-term impact on teaching performance.

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