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VISUALIZING NATURAL SCIENCE CONCEPTS WITH MIND MAPS TO PROMOTE NON-STANDARD THINKING SKILLS IN AI-DRIVEN EDUCATION

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Abstract: This paper examines the educational challenges emerging from the rapid expansion of scientific knowledge and the increasing integration of artificial intelligence (AI) into production and social systems. The development of artificial neural networks has enabled the creation of intelligent machines capable of performing tasks based on standard, algorithmic thinking, raising complex questions about future human–AI coexistence. In this context, the ability to generate non-standard thinking skills—such as intuition, imagination, empathy, and creative problem-solving—becomes a critical human advantage, as these competencies cannot be fully programmed into AI systems.

The study argues that one of the most urgent tasks of modern education is to develop effective pedagogical methods for fostering non-standard thinking skills among the Alpha generation. As a response to this challenge, the paper explores the use of Mind Maps as an effective tool for visualizing verbal information and stimulating cognitive processes associated with creative and non-standard thinking. Special attention is given to animated mind maps, which actively engage the right hemisphere of the brain and enhance imagination and associative thinking.

Based on theoretical analysis and educational practice, the article demonstrates how mind map–based visualization can support the development of both standard and non-standard thinking skills in primary school students while improving their engagement with natural science subjects in AI-driven educational environments.

Keywords: artificial intelligence; natural science education; mind maps; visualization; non-standard thinking; creative thinking; Alpha generation; imagination; cognitive skills development;

The rapid integration of artificial intelligence (AI) into production processes and the exponential growth of scientific knowledge pose serious challenges to contemporary education systems. At the beginning of the twentieth century, the total volume of scientific knowledge doubled approximately every fifty years; by the end of the century, this period had shortened to ten to fifteen years. Today, the pace of knowledge expansion has accelerated to one to one and a half years, and in the near future, it may take only a few months for scientific knowledge to double. Among recent scientific advances, developments in artificial intelligence are particularly significant.

In his seminal 1950 article "Computing Machinery and Intelligence", published in the journal Mind, the British mathematician and logician Alan Turing suggested that by the end of the century it would be reasonable to speak of thinking machines. Seventy-four years later, in 2024, the Nobel Prize in Physics was awarded to J. Hopfield and G. Hinton for their fundamental discoveries and inventions that enabled machine learning through artificial neural networks. These breakthroughs have made it possible to design intelligent systems capable of

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performing tasks that can be algorithmically defined and programmed, effectively creating machines that can imitate certain aspects of human thinking.

Currently, intensive efforts are underway to develop Artificial General Intelligence (AGI). In an interview with Time magazine, Demis Hassabis, CEO of Google DeepMind, emphasized that AGI will not only solve narrow, task-specific problems but will also possess the ability to apply knowledge across diverse domains at a level comparable to human intelligence. While such developments offer unprecedented technological opportunities, they also raise serious risks and ethical concerns.

Consequently, modern education systems face the critical task of preparing individuals who are capable of coexisting with AI-driven technologies, adapting to production environments based on the latest scientific achievements, and proposing non-standard solutions in uncertain and complex situations. According to Bill Gates, maintaining intellectual superiority over AI systems requires humans to remain one step ahead in the domain of thinking. This implies that education systems must cultivate cognitive skills that surpass those of artificial general intelligence, particularly in areas where machines remain limited.

This challenge is not unique to any single country. For instance, Singapore—whose students consistently achieve top results in international assessment studies—has initiated a large-scale technological transformation of its school education system planned through 2030 to sustain its competitive advantage. One of the key priorities of this reform is preparing teachers to teach effectively in the era of digital technologies by equipping them with advanced technological and pedagogical competencies. Similar initiatives are being implemented in several European countries with highly regarded education systems, where special emphasis is placed on developing twenty-first-century skills, particularly creativity and inventive thinking. In contrast, systematic research and large-scale implementation of such approaches remain limited in Uzbekistan, highlighting the need for focused pedagogical innovation and empirical investigation.

Artificial intelligence has the potential to bring revolutionary changes to industry, healthcare, and education. According to Geoffrey Hinton, often referred to as the “father of artificial intelligence,” AI-based individualized tutors can enable students to master educational content at twice the speed while significantly improving learning quality. Such systems are capable of identifying what a learner does not understand and determining what should be taught next. In this context, it has even been suggested that traditional higher education institutions may lose their central role in the future. Nevertheless, AI-driven systems remain limited to competencies that can be implemented through artificial neural networks. More precisely, they can perform only those forms of “creative thinking” that are algorithmically defined and programmable.

Under these conditions, it is appropriate to conceptualize creative thinking as comprising two distinct forms: standard thinking and non-standard thinking.

Standard thinking is a form of reasoning grounded in logic and analytical processes. It follows clear cause–effect relationships and aims to identify practical solutions to well-defined problems. In most cases, standard thinking represents the application of existing knowledge to new situations. This type of thinking is relatively simple and efficient because it relies on established cognitive pathways already tested by others. Consequently, the algorithmic nature of standard thinking makes it possible to formalize and teach it to machines. Individuals who primarily rely on standard thinking often function effectively as engineers, entrepreneurs,

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policymakers, or task executors; however, they rarely become groundbreaking innovators or discoverers.

In contrast, non-standard thinking represents a free and unconventional creative process characterized by the exploration of atypical pathways and original problem-solving strategies. It involves the ability to generate unexpected solutions and novel ideas that go beyond predefined algorithms. Non-standard thinking is deeply individual and is governed by affective and intuitive processes such as intuition, empathy, emotions, imagination, and fantasy. Historically, it is precisely this form of thinking that has enabled humanity to discover solutions previously unknown or considered unattainable. Unlike standard thinking, non-standard thinking cannot be programmed or transferred to artificial intelligence systems. Human intellectual superiority over AI can therefore be maintained only through the cultivation of non-standard thinking skills.

Non-standard thinking is a defining characteristic of outstanding scientists, artists, entrepreneurs, and visionary leaders. It stimulates the emergence of innovative ideas, creative breakthroughs, and the development of novel products and technologies. Without non-standard thinking skills, figures such as Amir Temur, Albert Einstein, Nikola Tesla, Thomas Edison, and Elon Musk would not have achieved their remarkable accomplishments.

In the era of artificial intelligence, the ability to formulate problems precisely and creatively becomes increasingly valuable, and individuals who possess this competence are highly sought after. The human capacity to generate original, non-standard ideas ensures a decisive advantage over artificial intelligence systems. For this reason, it is essential to begin developing non-standard thinking skills from an early age. One effective pedagogical tool for achieving this goal is the use of Mind Maps, which stimulate the right hemisphere of the brain and promote imagination and non-standard cognitive processes.

Furthermore, the transformation of education systems must take into account the psychological characteristics and learning preferences of the Alpha generation—individuals born from 2010 onward. This generation demonstrates a strong tendency toward clip-based thinking, meaning they perceive and process information primarily through short, visual, and fragmented content.

Artificial intelligence also enables the personalization of education by adapting learning processes to each student's interests, abilities, and learning pace. Such individualized learning environments allow students to acquire knowledge at convenient times and through engaging formats, including educational games. Members of the Alpha generation are likely to change their professions and workplaces multiple times throughout their lives, as it is predicted that up to 50 percent of existing occupations may undergo significant transformation in the near future. This reality places additional demands on teachers, who must continuously develop new competencies and adapt to rapidly evolving educational contexts.

At present, humans maintain a clear advantage over artificial intelligence in domains such as emotion, intuition, empathy, and imagination. In the AI era, these competencies will become far more valuable than encyclopedic knowledge alone. Consequently, the primary mission of modern education is to develop effective methods for cultivating these uniquely human skills. Within this framework, the role of the teacher must also change: rather than serving as an authoritarian figure, the teacher should function as a facilitator, mentor, and moderator who organizes and guides learning activities without excessive direct intervention. Although relatively few educators currently adopt this approach, systematic efforts are required to prepare and support teachers for this evolving role.

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For the Alpha generation, the ability to learn continuously and acquire new knowledge throughout life will be a core competence. Therefore, fostering creative thinking and a strong motivation for learning from an early age is essential. In a rapidly changing world, the capacity to adapt and generate new ideas will be more important than mastering a single profession.

Teaching students creative thinking begins with the development of their imagination. As emphasized by L. S. Vygotsky, no creative product can emerge without imagination. Imagination is nourished by perception, which is formed through information received via sensory channels. The richer and more vivid perception is, the more developed imagination becomes. Imagination represents a unique psychological state that exists between perception, thinking, and memory, distinguishing it from other mental processes.

One of the most effective methods for developing imagination and non-standard thinking skills is the use of Mind Maps. Mind maps are closely related to the functioning of the human brain and enable more efficient utilization of its cognitive potential. As a tool grounded in creative thinking, mind maps support the exploration and solution of complex problems by stimulating associative and imaginative processes.

Information obtained through sensory channels about an object—for example, an apple—forms a mental image in the brain. As a result, various imaginative associations related to the object emerge in the right hemisphere of the brain.

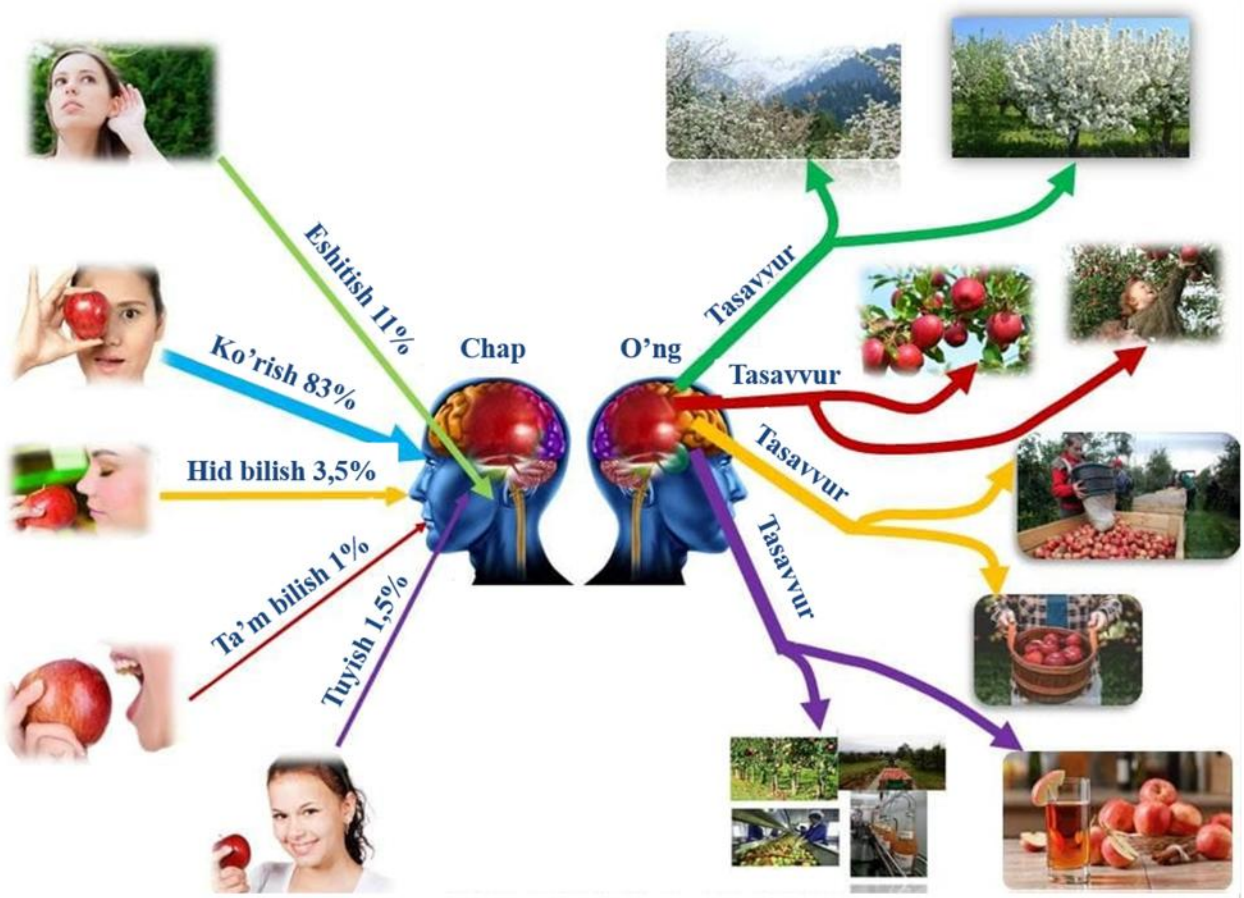

Figure 1. "Imagination" mind map

The mind map presented in Figure 1 illustrates blooming apple trees, baskets filled with red, pink, and green apples, orchards from which apples are harvested, decorated tables with

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plates of apples, and various apple juices consumed by children. This visualization reflects how sensory information transforms into diverse imaginative representations in the human mind.

On the one hand, the mind map demonstrates the mechanism of imagination, while on the other hand, it visually depicts the emergence of imaginative thinking itself. Asking students to continue these imaginative associations and illustrate them through drawings contributes significantly to the development of their imagination and creative thinking skills.

According to Roger Sperry’s theory on hemispheric specialization of the brain, the human brain consists of two hemispheres: the left and the right. The left hemisphere is primarily responsible for logic, analysis, language, speech, and mathematical processing, whereas the right hemisphere governs intuition, spatial imagination, empathy, emotions, analogy, metaphor, and fantasy. In the transition from the information age to the conceptual and AI-driven era, right-hemisphere-based thinking becomes increasingly important.

While the left hemisphere processes information sequentially, the right hemisphere interprets information visually and holistically, forming imaginative representations. In teaching natural sciences—particularly physics and biology—students’ capacity for imagination plays a crucial role. Many scientific concepts cannot be observed directly and can only be understood indirectly through experimental results, models, or technological instruments.

Indirect knowledge is acquired by enhancing human sensory perception or facilitating observation. This includes knowledge obtained through experimentation and modeling. At the same time, analytical thinking enables humans to overcome physiological limitations, allowing them to explore phenomena ranging from distant outer space to subatomic structures.

Several methods are commonly employed to acquire indirect knowledge:

Idealization, which involves creating idealized objects with certain limitations to study real phenomena (e.g., material point, ideal gas, perfectly rigid body);

Modeling, based on analogy, where complex or inaccessible objects are studied through simpler, analogous models;

Experimentation, which transforms humans from passive observers into active investigators of nature by using instruments that extend sensory capabilities;

Wave-based brain analysis, which allows conclusions to be drawn about which areas of the brain are involved in processing specific types of information.

Animated mind maps, as an effective tool for visualizing verbal information, significantly enhance students’ imaginative development.

Below, mind maps related to some of the most engaging natural science topics—“The Nature of Light” and “The World Around Us”—are presented.

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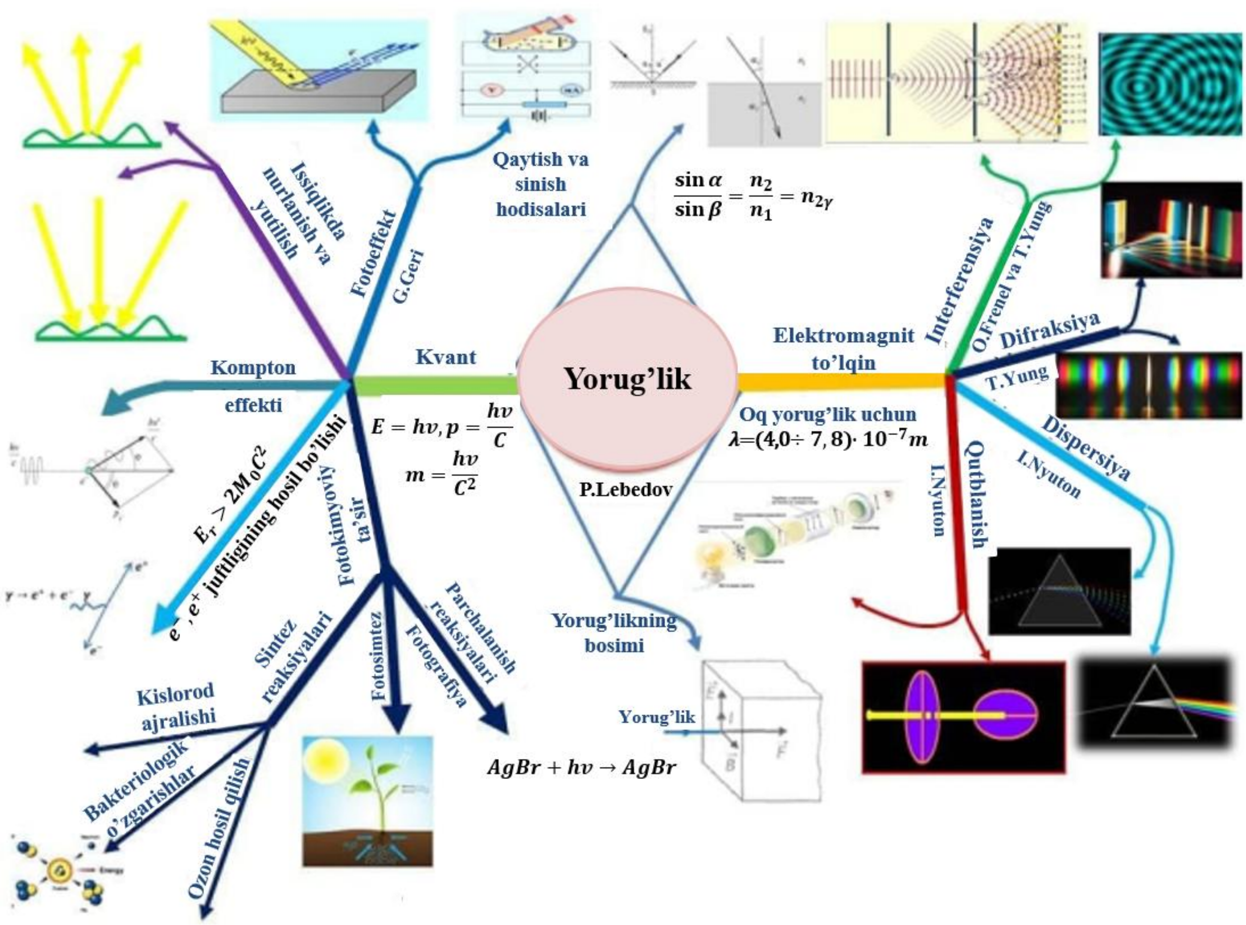

Figure 3. "The World Around Us" mind map

The "World Around Us" mind map presents integrated information about natural landscapes, animals, plants, vegetables, and fruits. This visualization encourages students to identify relationships, similarities, and unifying factors among elements of the natural environment, supporting holistic perception and non-standard cognitive processing.

The rapid growth of scientific knowledge worldwide and the increasing integration of artificial intelligence into production systems require education systems to prepare a generation capable of adapting to constantly changing conditions, proposing non-standard solutions in uncertain situations, and coexisting effectively with AI-driven technologies. These demands are particularly relevant for the Alpha generation, whose cognitive characteristics and learning preferences differ significantly from those of previous generations.

Modern education must therefore focus on developing skills that artificial intelligence systems cannot acquire, commonly referred to as soft skills. Although AI-driven robots are capable of mastering standard thinking skills and executing algorithmic tasks with high efficiency, they remain fundamentally limited in domains such as intuition, empathy, emotional intelligence, analogy, and metaphor—competencies that form the foundation of non-standard thinking. Consequently, fostering non-standard thinking skills becomes a strategic priority for ensuring human intellectual advantage in the AI era.

The findings of this study support the view that effective educational practices should account for the cognitive and psychological features of the Alpha generation. One of the most

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notable characteristics of this generation is a preference for visual, fragmented, and dynamic forms of information processing. In this context, Mind Maps represent a powerful pedagogical tool, as they integrate verbal and visual information while activating right-hemisphere cognitive processes associated with imagination and creativity.

The use of mind maps for visualizing verbal content not only enhances students' understanding of complex natural science concepts but also encourages associative thinking and imaginative exploration. When presented in animated form, mind maps further increase student engagement, motivation, and cognitive involvement, transforming the learning process into an interactive and meaningful experience. Such an approach aligns with contemporary constructivist and learner-centered educational paradigms, where students actively construct knowledge rather than passively receive information.

Moreover, the changing role of the teacher is a critical factor in implementing innovative educational methods. In AI-driven educational environments, teachers should move away from authoritarian instructional models and assume the roles of facilitators, mentors, and moderators of learning. By guiding students' cognitive activities without excessive direct intervention, educators can create conditions that support independent thinking, creativity, and lifelong learning skills. Although the number of teachers prepared to adopt this role remains limited, systematic professional development and targeted training programs can address this gap.

Overall, the discussion highlights that developing non-standard thinking skills is not an optional enhancement but a fundamental requirement of education in the era of artificial intelligence. The integration of mind maps as a visualization and cognitive development tool offers a practical and effective strategy for addressing this challenge. By fostering imagination, creativity, and flexible thinking, such approaches contribute to preparing students for a future in which adaptability and innovative problem-solving will be more valuable than the mastery of static knowledge.

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