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Assessing lateral thinking: validity, reliability, and universality using a novel verbal test

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Abstract. Lateral thinking, a key component of creative thinking, is crucial in problem-solving, scientific discovery, and everyday life. However, its assessment remains challenging due to its elusive nature. This study proposes and validates a novel verbal test to objectively measure lateral thinking. The test, consisting of triads of words with subtle associations, requires subjects to find commonalities between seemingly unrelated concepts. The study involves three groups: two student groups and one engineering group. Statistical analysis reveals that the test demonstrates validity, reliability, and representativeness. Notably, the probability distribution of the measured parameter shows low deviations from the normal law, suggesting that lateral thinking, like general intelligence, is a relatively universal personality trait. This work contributes to a deeper understanding of lateral thinking and provides a validated tool for its assessment, promoting creativity in education and various other fields.

Keywords: creative thinking, lateral thinking, cognitive assessment, creativity, verbal test, universality, personality traits

1. Introduction

The educational process is aimed not so much at the transfer of knowledge but at the development of thinking [5] and, in particular, creative thinking [3, 20]. This is the central task in the new programs created in connection with the modernization of the education system. This means that the teacher, along with the knowledge of modern approaches to improving the education system, in particular the STEM methodology [13, 15, 18], should be quite familiar with the psychology of thinking and the nature of creative thinking.

The problem of personality testing has a long history. Since ancient times, assessing and predicting human capabilities have been of fundamental and practical interest. Furthermore, creating psychological tests is essential in our time, a subject of numerous studies and discussions. A teacher's ability to assess students' abilities and creative potential determines the level of the educational process.

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There are different approaches to testing the intelligence and specific abilities of personality (Jesson [9], Katsko and Moiseienko [11], Kaufman [12]). They are widely discussed and criticized and, at the same time, are often used to solve practical issues. For example, one famous is Eysenck's IQ test (Cahan [2], Eysenck, Eysenck and Barrett [6]) for assessing the general intelligence. Many studies have been carried out using these tests in various countries, and these results are reflected in many publications (e.g., Cahan [2], Juškevič and Kopelevič [10]). For this test, the distribution of the probability of detecting a particular level of intelligence IQ follows a normal law.

The law of normal distribution means that the parameter values tend to concentrate around the value of the mathematical expectation. The variance determines the degree of spread of a random variable relative to the mathematical expectation. Any empirical distribution curve is characterized by two parameters: the coefficient, which determines the symmetry of the curve for the mathematical expectation (A_s), and the coefficient of kurtosis (E_x), which sets the "sharpness" of the distribution peak. In the case of a normal probability distribution law (Gaussian curve) [5] $A_s = 0$ and $E_x = 0$. Different laws of probability distribution describe psychological parameters characterizing personality.

The psychological characteristics of a person can be classified according to the degree of their universality. For example, general intelligence is a relatively universal characteristic of a person. All people have a certain level of intelligence. (We do not consider options of pathological psychological characteristics.)

At the same time, general intelligence is formed based on different individual abilities. The formation of general intelligence depends on memory (various types of memory), the peculiarities of thinking, in particular, creative thinking and other personality abilities. It is evident that the normal law of probability distribution, which is fulfilled for the IQ parameter, is not necessarily the case for other (less universal) psychological characteristics of a person. Therefore, we can judge the degree of universality of the psychological characteristics of a personality based on the proximity of the distribution function of its probability to the normal law.

Let us look at some different examples. What is the probability distribution for those with musical memory? The perception of music and musical memory characterize the emotional and psychological sphere of the personality, essentially determining its psychological portrait.

Outstanding scientists saw in music the highest manifestation of human intellectual achievements. Gottfried Wilhelm Leibniz wrote in the letter to Christian Goldbach: "Music is a secret arithmetic exercise of the soul, which calculates without knowing it" [17]. Helmholtz's research [2] touched upon various scientific and practical issues related to the problems of perception, creativity, diagnostics of abilities, and methods of musical education, which gave a powerful impetus to the development of almost all areas of musical psychology. At the same time, if we compare the distribution of the probability of manifestation of high general intelligence of IQ with the function of the probability of manifestation of musical memory, we can see significant differences (figure 1). They consist of the fact that in the latter case, the coefficient of kurtosis EX differs from zero, and the variance σ^2 is much less.

Let us turn to such a person's condition as depression. This condition is experienced by a significant proportion of the world's population. The probability distribution for carriers of this state differs from the normal law already in opposite signs: the distribution peak is sharply lowered, and the variance is sharply increased (figure 1).

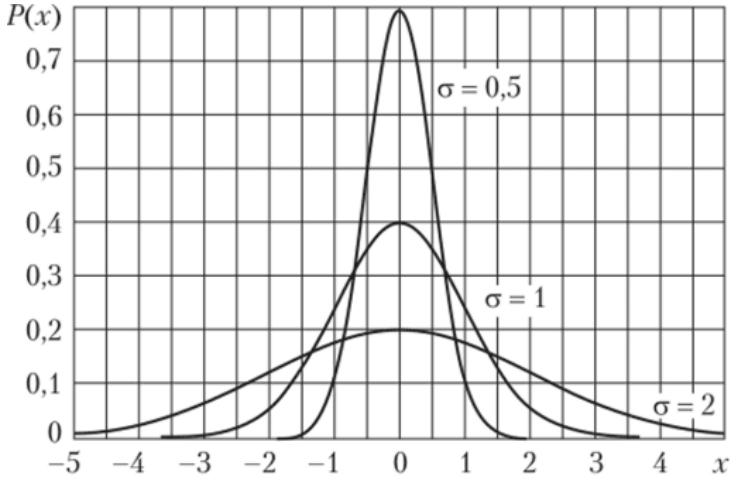

Figure 1: Illustration of the difference between the distribution curves for the parameters: IQ (σ =1), the parameter of musical memory (σ = 0.5) [19], the parameter of depression (σ = 2) [16].

Our work investigates lateral thinking as a critical component of creative thinking. Lateral thinking as a thought process was discovered by De Bono [4]. The essence of such a thought process is that we are distracted from the object in question and switch to another object, which at first glance has nothing to do with the first. However, new possibilities for considering the first object open up after such a transition. Albert Einstein said life is like a bicycle: "As soon as you stop pedalling, you fall" [1]. This is an excellent example of lateral thinking.

A creative process is better described as logical thinking, trial and error, feedback, and reflection. We accept such opportunities. However, there are many people whose experiments and articles show that training and developing lateral thinking improves the emergence of creative solutions in standard or stressful situations [14]. There are guidelines for developing lateral thinking. However, to track the development of lateral thinking, measuring it is necessary.

It is known that all scientific research tends to use models. Lateral thinking is manifested in this. The scientific result depends on a well-chosen model. The famous models are used in the natural sciences, particularly in physics: models of atoms, atomic nuclei, crystals, etc.

In cosmology, models of the Universe are being widely studied and discussed.

Our work aims to draw attention to the problem of the development and use of lateral thinking. A task was set to compile a questionnaire to test lateral thinking. An experiment was carried out with groups of students and engineering workers. The probability distribution functions for the studied groups are obtained and analyzed.

2. Testing lateral thinking

Among the tests designed to assess the parameters of thinking, more is needed to determine the level of lateral thinking. This is because some psychologists underestimate the role of lateral thinking in the creative process. However, understanding the essence of lateral thinking and its development in students is necessary to increase the individual's creative potential. A possible

approach for assessing the level of lateral thinking is proposed below.

2.1. Test questions formulation principle

In the case of lateral thinking, unobvious special "associations" take place. These are associations that are not caused by the external similarity of objects. In this case, objects and phenomena are compared based on the subjective view of a person having his vision. A typical example is the creation by physicists of a model for the fission of an atomic nucleus. Frenkel and Weizsaeker "saw" in the atomic nucleus a drop that drains from a drainpipe during rain [7]. The picture of the separation of a drop from a pipe led to the thought of a drip mechanism of nuclear fission. The drop model of the atomic nucleus is described in all textbooks on nuclear physics [8]. The question of interest is the extent to which lateral thinking is present in human thinking at various levels. In drawing up a questionnaire for assessing lateral thinking, we chose triads of words in which two words are far from each other in content, and two are close. It is proposed to determine two words that, at first glance, are in no way linked associatively and try to find something common in these words. The questionnaire is attached in figure 2. It has been checked following the requirements for tests (section 2.3).

2.2. Description of experimental results

For the study, three groups of subjects were selected, of which two groups were students (140 and 70 people) aged 19–22 and a group of engineers and technicians (56 people) aged 30–45 years. A questionnaire was used to assess the level of lateral thinking (figure 2). The content of the questionnaire and the principle of assessing the correctness of the answer are described above.

No suggested choices for matching word pairs were provided. It was suggested to make an appropriate choice of two words and provide a short justification for the choice made in each case, similar to those on the right side of the figure 2. The choices and rationale may differ from those suggested in figure 2.

The ratio of the number of (n) triads in which the corresponding pairs of words were correctly selected to the total number (N) of triads (in figure 1) was used as a parameter characterizing the level of lateral thinking ($LT = n/N$).

Using the obtained data, in all cases, the parameter distribution characteristics were calculated: average values of the measured value ($\overline{x}$), mathematical expectations (μ), standard deviations (σ), third moment of inertia (μ_3) and fourth moment of inertia (μ_4). The results are shown in table 1.

Table 1
Characteristics of parameter LT distribution for studied groups.

Number of group	$\overline{x}$	σ	μ_3	μ_4
1	0.43	0.65	0.05	0.48
2	0.37	0.68	0.10	0.44
3	0.32	0.54	0.02	0.42

River	Sunset	A life	The flow of the river is usually associated with the flow of life, but in the case of lateral thinking, the combination "Sunset of life" is applicable.
Crimes	Hurricanes	Cataclysms	Hurricanes and cataclysms are related concepts, but crimes as cataclysms are a lateral vision of the subject.
Hunger	Loneliness	Insulation	Loneliness and isolation are close concepts, but a person who thinks laterally understands loneliness as a hunger for communication.
Eye	Sadness	Depth	The expression "sad gaze" is often encountered, but the expression "deep gaze" already indicates more lateral vision.
Mountain	Barrier	Patience	Climbing the mountain naturally requires preparation and patience, but overcoming any barrier also requires preparation and patience.
Needle	Spark	Think	Thought flares up like a spark, and sometimes pierces like a needle.
Cloud	Sea	Sky	The sea is usually associated with the sky, but in the case of lateral thinking, a person compares the sea with a field (he sees wheat stalks swaying in the wind).
Wind	Hurricanes	Think	The wind is naturally associated with hurricanes, but it happens that "the wind walks in the head."
Face	Portrait	Decision	The face is naturally associated with the portrait, but you can talk about a decisive facial expression.
Find	Art	Eureka	Eureka is the intuitive finding of a solution, also an unexpected image in art.
Science	Target	Vertex	Science is aimed at achieving a specific goal, but it is also the pinnacle of human intellectual activity.
Song	Soul	Life	Of course, there is the soul in the song, but spirituality is the basis of life.
Thoughts	Mysteries	Horses	There are secret thoughts, but you can imagine "thoughts - horses".
Steps	Tops	Run	Running is quick steps, but steps can be thought of as moving to the top.
Road	Lights	End	The road is usually associated with road lights, but in the case of lateral thinking, the words "lights" and "end" are chosen (light at the end of the tunnel).
Poems	Formulas	Regulations	Formulas describe laws, but poetry obeys its own laws.
Friend	Present	The God	The best gift from God is good friends.
Libra	Character	Sensitivity	It is important to have a sensitive scale, but also a sensitive character.
Neighbor	Character	Enemy	The enemy can be a neighbor, but also your own character.
Rescue	Berry	Horse	Both a horse and a berry can save.
Wood	Family	House	The family is associated with the home, but there is also a family tree.
Chord	Disappointment	Note	A chord is associated with a note, but there is also a "disappointment note".
Bicycle	A life	Snake	Life wriggles like a snake, but "looks more like a bicycle" (A. Einstein).
Bonfire	Fire	Ice	Bonfire is associated with a fire, but "ice and fire" appears in poetry (A. Pushkin)
Autumn	Evening	Sunset	Evening is associated with sunset, and in the case of lateral thinking, autumn is perceived as sunset of the year (or sunset of life).

Figure 2: Questionnaire for testing lateral thinking. The words of the recommended choice are underlined.

Table 2
Values A_s and E_x for studied groups.

Number of group	A_s	E_x
3	0.7	-0.53
1	0.18	-0.18
2	0.32	-0.98

Using the data in table 1, we calculate the values for the coefficients of skewness (A_s) and kurtosis (E_s): $A_s = \mu_3 / \sigma_3$ and $E_x = (\mu_4 / \sigma_4) - 3$. The results are presented in table 2.

Figure 3 shows the experimental distribution of the parameter LT for the first group.

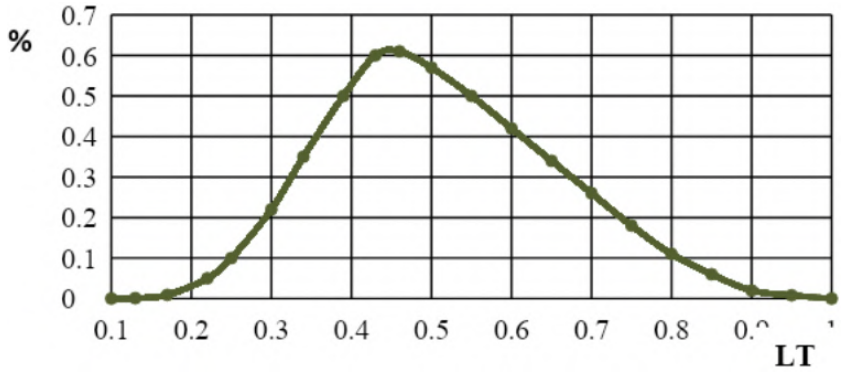

Figure 3: Experimental distribution of the parameter LT for the first group.

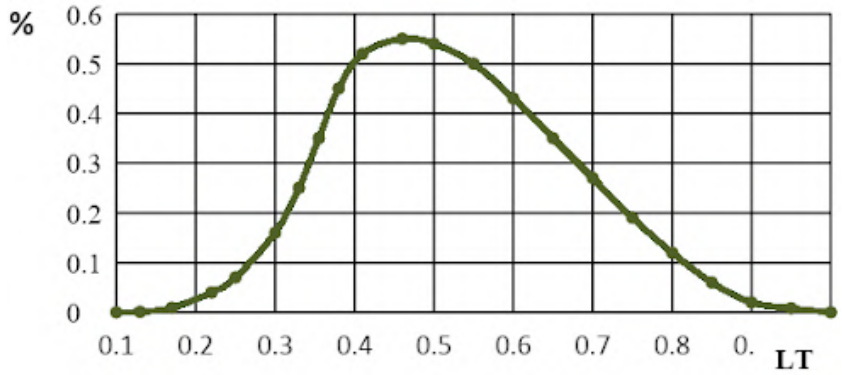

Figure 4: Experimental distribution of the parameter LT for the second group.

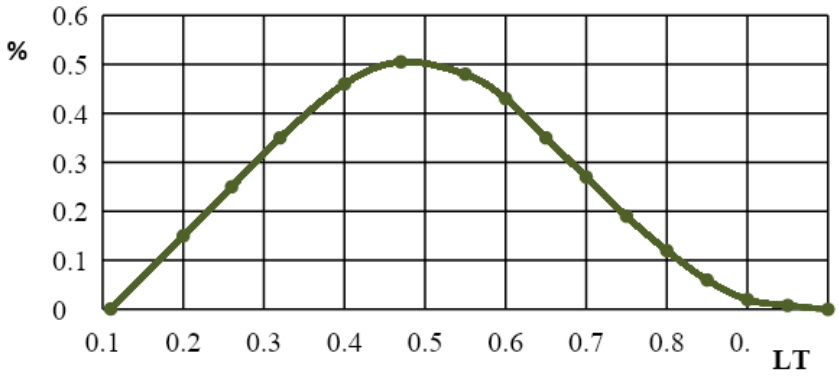

Figure 5: Experimental distribution of the parameter LT for the third group.

2.3. Checking the applied test

2.3.1. Validity of the test

Validity is checked as the correspondence of the measured parameter to the psychological characteristic that is being studied. In our case, we are talking about the assessment of lateral thinking. Therefore, during the testing process, a survey was conducted to determine the unity of the chosen word pairs a person implied. For the correct result to be counted, the test taker must explain his choice in the spirit of the comment in figure 2. This explanation did not need to coincide with the comment in figure 2. The main requirement was that the original vision manifested the subject in interpreting the unity of the objects being compared. Situations arose when the subject chose objects that had an obvious commonality. However, simultaneously, a "lateral" vision was manifested, and the unity of objects that another person could not notice was noted. Thus, the parameter $LT = n/25$ was determined for each subject in all three groups.

2.3.2. Test reliability

Reliability of the test involves obtaining close results in repeated measurements and for subjects whose parameters differ little. To check the test reliability, we tested the studied groups at different times with an interval of two to three months. We obtained similar test results due to multiple measurements of the parameters of the same group. Discrepancies in the parameters of the various groups also persisted.

2.3.3. Representativeness of test

Representativeness suggests that test results for a specific group represent a large part of the population. To check the compliance of the test with this characteristic, we have taken two groups with twice as different the number of subjects (70 and 140). Both groups select the contingent with close characteristics (educational level, professional qualifications, etc.). We obtained that in these groups, the experimental results for the studied parameter (LT) differ slightly (table 1).

2.4. An example when studying vacancies in crystals

When studying the natural structure of crystals, the concept of a vacancy (an empty place from which an atom is left) and an interstitial atom (an atom that left its place with the emergence of a vacancy) are introduced. A so-called Frenkel pair is formed if an atom leaves close to its vacancy. However, an intermediate variant is possible when the atom does not move far enough from the vacancy, and the vacancy pulls it back in. When this process is repeated, a so-called "blinking vacancy" appears. Such a vacancy either appears or is "healed" by the returned atom. The concept of a "blinking vacancy" appeared relatively recently [22]. Physicists came up with the idea of a blinking vacancy by observing raindrops falling on the calm surface of a river. Raindrops leave a mark on the water, which disappears with a blink. This is a typical example of lateral thinking, just like in the case of nuclear fission above [8] (figure 6).

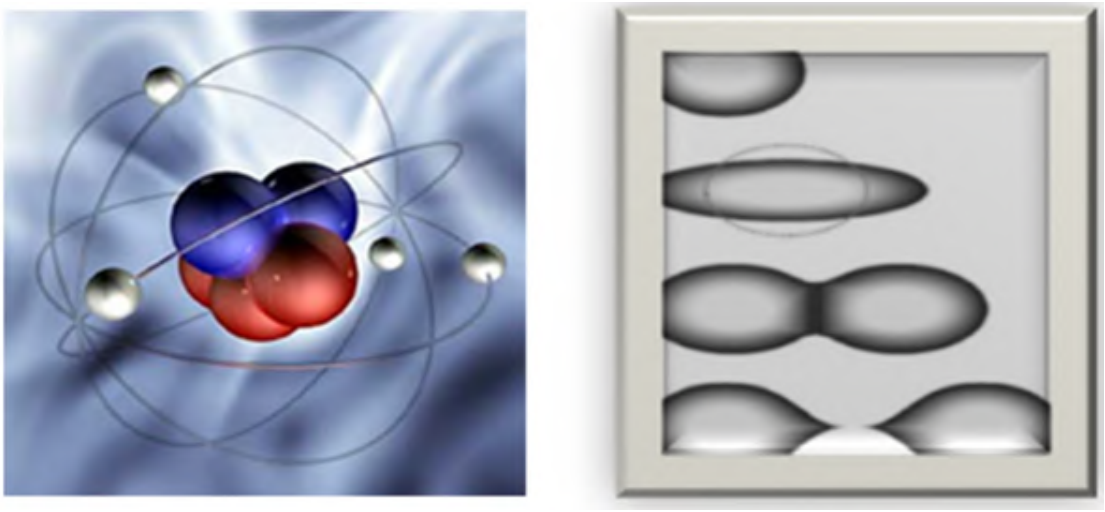

Figure 6: Illustration for the droplet model of the fission of an atomic nucleus. Left is an image of an atomic nucleus; on the right is an image of the fission of a liquid drop.

3. Discussion

The problem of thinking, one of psychology's central problems, needs to be given more attention in addressing issues of improving the education system, new methodological approaches, and developing new curricula. Despite the ambiguous attitude of psychologists and teachers to existing models and ideas about the mechanisms of thinking, it is helpful to consider the use of accumulated experience and ideas in the educational process. The concepts of productive thinking introduced by Wertheimer [21], the concepts of lateral thinking introduced by De Bono [4] and other well-known models of thinking [23] must be taken into account in the learning process when solving specific methodological problems. The teacher's attention should be focused not only on effectively communicating knowledge but also on choosing a teaching method that develops thinking. Therefore, assessing the student's ability to think in a certain way is vital.

In this work, we investigated the possibilities of objectively assessing lateral thinking. Testing this thinking requires special care since it is about more than solving specific tasks. It is required to trace the course of a person's thinking and to distinguish the degree of originality of various approaches to assessing the meaning of concepts.

In many life cases, a person needs to apply lateral thinking in scientific research, in the perception of humour and in everyday life. When compiling a questionnaire for assessing the level of lateral thinking, we tried to allow the subject to find a wide range of associations.

The proposed test has been verified in terms of validity, reliability and representativeness. During the experiment, however, an additional approach was applied to assess the significance of this test. It is known that the probability distribution of detecting a specific value of the measured parameter during testing is typical for a particular test. In the case of measuring the IQ parameter, this probability distribution obeys the normal law. The IQ parameter is a relatively universal characteristic of a person. This parameter characterizes any person (except for pathological cases). It can be assumed that the closer the probability distribution of a given parameter is to the normal law, the more universal psychological characteristics of this parameter.

In the case of testing lateral thinking, an insignificant deviation of the measured empirical distribution of the probability of the LT parameter from the normal law was revealed, which indicates a reasonably high universality of this personality characteristic.

4. Conclusion

The research presented in this paper focused on assessing lateral thinking as a crucial component of creative thinking. Lateral thinking, characterized by the ability to explore unconventional associations and perspectives, was examined through a carefully designed verbal test involving triads of words.

The experiment involved three groups of participants, including students and engineering professionals. The results were analyzed, and the probability distribution of the lateral thinking parameter (LT) was evaluated. The empirical distributions exhibited only minor deviations from the normal law, indicating a relatively high universality of lateral thinking as a psychological characteristic.

The proposed test's validity, reliability, and representativeness were thoroughly examined. Additionally, comparisons were drawn with the well-established Eysenck IQ test, emphasizing the potential generalizability of lateral thinking as a trait akin to general intelligence.

The findings underscore the importance of considering lateral thinking in educational contexts, where fostering creative problem-solving and innovative thinking is paramount. The proposed test provides a valuable tool for objectively assessing and tracking the development of lateral thinking in individuals. Educators and psychologists can use this information to tailor teaching methods that specifically nurture lateral thinking skills, contributing to enhancing creative potential.

A broader and more diverse sample could be considered in future research to further validate the test's generalizability. Additionally, exploring the relationship between lateral thinking and other cognitive abilities could provide deeper insights into the multifaceted nature of human

intelligence and creativity.

References

[1] Albert Einstein, 2016. In: S. Ratcliffe, ed. *Oxford essential quotations*. 4th ed. Oxford University Press. Available from: https://doi.org/10.1093/acref/9780191826719.013.q-oro-ed4-00003988.

[2] Cahan, D., 2018. *Helmholtz: A Life in Science*. Chicago: University of Chicago Press.

[3] Chen, Y., Spagna, A., Wu, T., Kim, T.H., Wu, Q., Chen, C., Wu, Y. and Fan, J., 2019. Testing a Cognitive Control Model of Human Intelligence. *Scientific Reports*, 9(1), p.2898. Available from: https://doi.org/10.1038/s41598-019-39685-2.

[4] De Bono, E., 2015. *Lateral thinking: creativity step by step*. New York: Harper Colophon.

[5] Dickens, W.T. and Flynn, J.R., 2001. Heritability estimates versus large environmental effects: the IQ paradox resolved psychological review. *Psychological review*, 108(2), pp.346–369. Available from: https://doi.org/10.1037/0033-295x.108.2.346.

[6] Eysenck, S.B.G., Eysenck, H.J. and Barrett, P., 1985. A revised version of the psychoticism scale. *Personality and Individual Differences*, 6(1), pp.21–29. Available from: https://doi.org/10.1016/0191-8869(85)90026-1.

[7] Frenkel, V.Y., 1996. *Yakov Ilich Frenkel: His work, life and letters*. Birkhäuser Basel.

[8] Hawking, S., 2018. *Brief Answers to the Big Questions*. New York: Bantam.

[9] Jesson, J., 2012. *Developing Creativity in the Primary School*. Berkshire: Open University Press.

[10] Juškevič, A.P. and Kopelevič, J.K., 1994. *Christian Goldbach 1690–1764*, *Vita Mathematic*, vol. 8. Birkhäuser Basel. Available from: https://doi.org/10.1007/978-3-0348-7382-6.

[11] Katsko, O.O. and Moiseienko, N.V., 2018. Development computer games on the Unity game engine for research of elements of the cognitive thinking in the playing process. *CEUR Workshop Proceedings*, 2292, pp.151–155.

[12] Kaufman, A.S., 2009. *IQ Testing 101*. New York: Springer Publishing.

[13] Kukharchuk, R.P., Vakaliuk, T.A., Zaika, O.V., Riabko, A.V. and Medvediev, M.G., 2023. Implementation of STEM learning technology in the process of calibrating an NTC thermistor and developing an electronic thermometer based on it. *CTE Workshop Proceedings*, 10, p.251–264. Available from: https://doi.org/10.55056/cte.560.

[14] Mellenbergh, G.J., 1989. Item bias and item response theory. *International Journal of Educational Research*, 13(2), pp.127–143. Available from: https://doi.org/10.1016/0883-0355(89)90002-5.

[15] Mintii, M.M., 2023. Exploring the landscape of STEM education and personnel training: a comprehensive systematic review. *Educational Dimension*, 9, p.149–172. Available from: https://doi.org/10.31812/ed.583.

[16] Mozhaleva, N.G., 2015. Musical abilities, their nature and development during the instrumental music performance teacher training. *Educational dimension*, 44, pp.98–104. Available from: https://doi.org/10.31812/educdim.v44i0.2658.

[17] Patel, J.K. and Read, C.B., 1996. *Handbook of the Normal Distribution*, *STATISTICS: textbooks and monographs*, vol. 150. 2nd ed. New York, Basel, Hong Kong: Marcel Dekker.

[18] Shapovalov, Y.B., Bilyk, Z.I., Usenko, S.A., Shapovalov, V.B., Postova, K.H., Zhadan, S.O. and Antonenko, P.D., 2023. Harnessing personal smart tools for enhanced STEM education: exploring IoT integration. *Educational Technology Quarterly*, 2023(2), p.210–232. Available from: https://doi.org/10.55056/etq.604.

[19] Stough, C., Kerkin, B., Bates, T. and Mangan, G., 1994. Music and spatial IQ. *Personality and Individual Differences*, 17(5), p.695. Available from: https://doi.org/10.1016/0191-8869(94)90145-7.

[20] Vlasenko, K., Achkan, V., Chumak, O., Lovianova, I. and Armash, T., 2020. Problem-based approach to develop creative thinking in students majoring in mathematics at teacher training universities. *Universal Journal of Educational Research*, 8(7), pp.2853–2863. Available from: https://doi.org/10.13189/ujer.2020.080712.

[21] Wertheimer, M., 2020. Productive Thinking (1945). In: V. Sarris, ed. *Max Wertheimer Productive Thinking*. Cham: Springer International Publishing, pp.25–257. Available from: https://doi.org/10.1007/978-3-030-36063-4_2.

[22] *Yakov Evseevich Geguzin: to the 100th anniversary of his birth*, 2018. Kharkiv: Folio.

[23] Young, I., 2008. *Mental Models: Aligning Design Strategy with Human Behavior*. New York: Rosenfeld Media.