



Games for Science Education: Is this technique effective for developing students' creativity and scientific competence?

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Abstract

The authors examine the pros and cons of games in the context of increasing students' creativity and scientific competence. Research materials and methods consisted of two tests. The first included the use of 7 pedagogical methods that are valid for the mental diagnosis of students: speed of thinking; method of thinking flexibility; method of determining the level of imagination and others. After the first testing, the training program included techniques for playing chess (in the classroom and online) and sand animation (in the classroom). Re-testing was carried out to assess the effectiveness of the programs. The study results showed that play activities improve the quality of student learning both in the classroom and online and enhance the functioning of many processes, including the speed and flexibility of thinking, memory capacity and attentiveness. This study demonstrates that play activities used in the educational process can play a positive role in teaching students. Further research needs to focus on studying the role of age, gender and race in play activities and determine how these factors affect performance.

Keywords: chess, cognitive processes, natural science education, pedagogical methods, performance, play activity, thinking.

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1. Introduction

A game is an important component of a person's educational activity; it is a school of life and development practice. The pedagogical significance of a game as a form of education lies in the development of the necessary professional skills and abilities, as well as cognitive and personal qualities. Today, the transformation of the educational process is taking place, with the predominant use of distance learning forms and an emphasis on students' independent work. Changes in the learning environment actualize the search for new effective teaching methods, among which games attract special attention as a means of dynamic modeling of reality, development of intellectual abilities, formation of communication skills and professional competencies. However, despite many diverse publications and discoveries, from mathematical game theory to business and educational games, the impact of educational games on stimulating the cognitive aspects of students' creativity remains insufficiently studied. This determines the relevance of the current research, which is only a small particle in the infinite universe of games.

1.1. Conceptual or Theoretical Framework

In psychology, various methods of perceiving the level of cognitive skills of students are actively used. Just memorizing the material is no longer relevant and effective for the education sector and in the modern world it is necessary to focus on the ability of students to find ways out of various situations, to apply logical and creative thinking. For the development of logic, the ability to build a strategy and find ways out of various situations, various games are well suited. The game of chess has a particularly positive effect. As a strategic game, chess allows one to qualitatively develop the skills of identifying cause-and-effect relationships, revealing one's potential, the ability to build a strategy, solve a complex problem, think in a specific moment and in advance. The game of chess is used by many psychologists to develop the mental abilities and skills of schoolchildren and students, as well as to prevent dementia in the elderly.

Sand therapy is a technique described by scientists Margaret Lowenfeld in 1929 as a counseling method called "World Building" and Dora Kalff, who developed the theoretical principles of this technique, based on the Jungian approach in the 1950s. This therapy is especially effective for psychological diagnostics of children. With the help of drawings, they can convey their state, reflect some moments from life, share experiences that cannot be described in words. Contact with sand calms the child. This technique also allows one to develop creativity. It is effective and not very stressful.

The use of game techniques aimed at developing cognitive abilities in preschool and primary school children increases their interest in academic subjects and forms the prerequisites for further research activities. As educational entertainment, it is proposed, first of all, to integrate art into scientific disciplines (Stagg & Verde, 2019).

It is recommended to support science education through interactive blended learning using information and communication technologies (ICTs) as a model for scientific learning activities (Bidarra & Rusman, 2017). Researchers tend to view teaching methods as the reason that modern students are not attracted to science. The solution might be the mixed learning scenarios using modern technologies, including mobile devices, augmented and virtual reality (Romanova et al., 2020).

The formation of effective educational practices should be based on the combination of knowledge from various fields - biological and neurobiological sciences, psychology, sociology, pedagogy. Productive student learning and development depend both on the level of training of teachers and on the development of a well-thought-out curriculum and assessment system, and most importantly, on how the needs of students are taken into account (Ryabov et al., 2019).

It has long been proved that the introduction of elements of creative pedagogy has a positive effect on the creativity of students, therefore it is necessary to include its methods and tools in the educational process at the academic level (Mroczek-Żulicka & Mokras-Grabowska, 2021). Pedagogical practices aimed at fostering critical thinking, contributing to the development of the creative intelligence of students, should include a dialogical basis, interdisciplinarity, creative environment, encouraging non-standard thinking. Classes with ICTs, models and simulations, educational activities, excursions, and presentation by students of their own results can be considered as a contextual basis for the cognitive development of students (Purković & Kovačević, 2020).

The development of psychological and pedagogical technologies aimed at the development of potential abilities and capabilities, innovativeness, and creativity of students in the educational university environment is an urgent problem. The achievement of this result is directly related to a teacher's ability to create a proactive educational environment (Tsankov, 2018). A technologically rich educational environment stimulates students' desire to achieve academic success, and a purposeful game is a means of achieving desired learning outcomes.

However, the problem of internet addiction is a source of concern and prejudice about digital games, which are seen as a risk factor for mental health problems (Daniyarova et al., 2020).

To prevent the negative impact of educational games, it is recommended to adhere to a number of principles, including:

- compliance of content with development objectives;
- integration of theoretical foundations from the field of science studies;
- a social context in learning;
- development of diverse content;
- creating an optimal balance between a game and real learning opportunities.

It is argued that the use of an education model that combines digital tools with tutoring technologies is a new trend that opens up new opportunities, promotes the development of necessary skills based on digital literacy, provides equal access for everyone, and as a result, graduates are in demand in the global labor market (E.A. Makarova & E.L. Makarova, 2018). System design in the form of a cognitive dialogue game (DiaCog), using the structure of students' thinking in online dialogue, tracks students' learning level (Karahoca et al., 2018). Students learning using a VR-based game approach demonstrate greater creativity and higher cognitive performance, behavioral, emotional, and social engagement (Guan et al., 2021). The latter indicates the benefits of a game in the educational process and its importance in the life of every person (Rathunde & Isabella, 2020).

Purpose of the study - to study the role of educational games in stimulating the cognitive aspects of creativity in the scientific education of students.

1.2. Research objectives

- Analyze scientific literature data on the role of games in the educational process and the development of cognitive aspects of creativity.
- Study the influence of educational games on the cognitive aspects of students' creativity.
- Research hypothesis: educational games stimulate the cognitive aspects of creativity in students' science education.

2. Materials and Methods

To study the influence of educational games on the cognitive aspects of scientific creativity, it was decided to use the game of chess, which is known to develop logical thinking, memory, attention, and other cognitive processes of a person. Chess was chosen for the study as it is a logic game that combines elements of art, science and sport, which can be played remotely (Ovakimyan, 2019). In psychology, chess is used as a means of identifying and healing internal conflicts, understanding the cause-and-effect relationships of current events, developing planning skills and achieving goals, cognitive development and disclosing the creative potential of a person (Fadul, 2015). A sand therapy technique was also used, which was carried out in the classroom as well. Sandplay was first described as a counseling technique by Margaret Lowenfeld in 1929 called World Building, and Dora Kalff developed the theoretical principles of the Sandplay technique based on the Jungian approach in the 1950s. Psychodiagnostic methods (A. Z. Psychology, n.d.), which were used to study cognitive processes and a person's ability to creative activity, are presented in Table 1.

Table 1. Psychodiagnostic methods, which were used to study cognitive processes and a person's ability to creative activity

No.	Methods	Description of the method
1.	Research methodology for the speed of thinking and mobility of nervous processes	The method allows one to determine the pace of indicative and operational thinking components. A subject is asked to write the missing letters in the words. Execution time - 3 minutes. The number of correctly composed words is counted. Evaluation of the result: less than 20 words - low speed of thinking and mobility of nervous processes, 21-30 words - average, 31 or more words - high.
2.	Research methodology for thinking flexibility	The methodology is aimed at determining the variability of approaches, hypotheses, initial data, points of view, operations involved in the process of mental activity. The subjects are offered anagrams - sets of letters from which they must form words without missing or adding a single letter. An indicator of the flexibility of thinking is the number of correctly composed words within 3 minutes. High level of thinking flexibility - 26 or more words, medium - 21-25 words, low - 11-20 words.
3.	Methodology for determining the level of imagination	Test methodology consisting of 12 questions. 14-17 points - rich imagination, great creativity; 9-13 points - average imagination, found in most people; 5-8 points - a realist with an undeveloped imagination.
4.	Method for researching the creative potential of a	Test complex methodology, consisting of 18 questions, where questions 1, 6, 7, 8 define the boundaries of curiosity, questions 9 and 15 - constancy, question 10 - ambition, questions 12 and 13 - auditory memory, question 11 - visual memory, question 14 - the desire for independence, questions 16 and 17 - the ability to

	person	abstract, and question 18 - the degree of focus. The total amount of points shows the level of the personality's creative potential: 49 and more points - significant creative potential; 24-48 points - normal creativity, but there are problems that hinder the process of creativity; 23 or fewer points - lack of creativity.
5.	“Caesar” methodology (Diagnostics of working memory and attention)	The technique is a series of 8 tables of varying degrees of complexity, in which a number of meaningless sets of letters are presented. It is necessary to determine which of these combinations occurs most often in each of the tables. Working memory is designed to preserve working information for a short time. People with high working memory capacity can easily perform both simple and complex cognitive actions, while those with limited working memory capacity are quickly lost in complex situations saturated with information. Working memory capacity assumes not only perception of information, but also active and repeated use of information stored in memory.
6.	Methodology for diagnosing cognitive integration and differentiation	<p>With the help of this projective interpretive technique, consisting of unstructured tasks that allow for a variety of answers (15 plot pictures that should be described), stylistic features of thinking associated with the perception and personality as a whole are assessed. The technique is a fairly stable characteristic of a personality at a certain stage of its development, however, it is in dynamics and change, and is especially dependent on learning technologies. The main parameters of the cognitive style are the generalization of the “image of the world” (its abstractness-concreteness), the emotional saturation of cognitive processes, and an individual's activity. The “integration” pole is characterized by a high level of abstract thinking, due to which the world seems more integral and unified, while the “differentiation” pole is represented by the concreteness of thinking, the fragmented perception of reality.</p> <p>Within cognitive integration, two strategies are distinguished: theoretical - if the proposed situation is assessed using one, usually abstract concept that symbolizes the meaning of this situation, and action strategy - when the presented object is assessed as a single integral image, but at the same time is considered in action.</p> <p>Within cognitive differentiation, three strategies are identified: theoretical - if the situation is assessed statically and ends with its differentiation into several objects; action strategy - the situation and objects are considered in action; emotional - objects are not just analyzed in dynamics, but with emotional component due to the introduction of a plot or the use of emotionally colored definitions.</p>
7.	Embedded Figures Test (EFT)	Using this technique, the parameter “field dependence/independence” is measured. Field-dependent people usually prefer the collective performance of a task and choose an occupation in which the means of activity are predetermined and agreed upon. Field-independent people, on the other hand, choose a field of activity that requires high independence in the means to achieve the set goal. That is, the activity of the field-independent people is analytical, and the perception of the field-dependent ones is synthetic.

2.1. Sample

To implement the goal and objectives of the study, three groups of students of the Moscow State University, Amur State University, and Abai Kazakh National Pedagogical University were involved. The representativeness of the sample was ensured by simple random sampling. Equalization of groups through the randomization procedure is the only reliable way to eliminate the influence of external (additional) variables on the dependent. One group (A), in the amount of 315 people, was engaged remotely; chess lessons were additionally included in the educational process of this group. The

second group (B) - 127 students from the Moscow State University and 216 students from the Amur State University (343 people in total) were engaged in chess lessons in the classroom. In the third group (C), which consisted of 135 students of the Moscow State University and 206 students of the Amur State University and students of the Abai Kazakh National Pedagogical University (331 people in total), a creative game using sand therapy was conducted in the classroom. Classes were held every other day for three months (September-November 2020). At the beginning (1) and at the end (2) of the study, a psychodiagnostic study of the cognitive processes and creative abilities of the subjects was carried out.

Statistical processing - using the online program medstatistic.ru it was possible to carry out the necessary testing and, on the basis of the results, form the conclusions of this study.

Research limitations were associated with the specificity of the tasks set, as a result of which the authors studied the effect on cognitive creative processes of only two types of game. Thus, future studies may include business games, developing games for children, psychophysiological parameters, and mathematical game theory; they may also focus not only on university students but also people with disabilities, as well as differentiate respondents by gender and age. Thus, this pilot study can become the basis for a fairly wide area of further work.

Ethical issues assumed compliance with the principles of bioethics, ensuring anonymity and confidentiality in relation to respondents. The study did not involve additional funding, and there was no conflict of interest.

3. Results and Discussion

The study of the subjects using the methodology for studying the speed of thinking and the mobility of nervous processes made it possible to determine that in most of them (65-70%) this cognitive parameter was initially at an average level. In about a fifth of the subjects, a high indicator of the speed of thinking and mobility of nervous processes was revealed, while in 13-14% of cases the parameters of this test were at a low level (Table 2).

Table 2. Research methodology for the speed of thinking and mobility of nervous processes.

The speed of thinking and mobility of nervous processes	Group											
	A				B				C			
	1		2		1		2		1		2	
	n	%	n	%	n	%	n	%	n	%	n	%
high	65	20.6	127	40.3	68	19.8	142	41.4	67	20.2	115	34.7
average	219	69.5	180	57.2	228	66.5	196	57.1	220	66.5	209	63.2
low	41	13.0	8	2.5	47	13.7	5	1.5	44	13.3	7	2.1
Total	315	100	315	100	343	100	343	100	331	100	331	100
Student's t-test	3.754				3.973				2.037			
p	<0.05				<0.05				<0.05			
Correlation coefficient	1.000				1.000				1.000			

It should be noted that the authors carried out preliminary studies in each of the groups of subjects separately, but the obtained data indicated that there were no significant differences between these groups. Thus, all three groups of the studied students were initially comparable in terms of age, gender, and initial parameters of cognitive processes and creative activity. Table 2 shows that the indicators of the speed of thinking and mobility of nervous processes in the last study improved significantly, but this change was more significant in the groups of students involved in chess, both in

the classroom and online. The indicators of those who studied online, in addition, although not significantly, were slightly higher than those of those who studied in the classroom, mainly due to a decrease in low indicators and an increase in high ones. In the group engaged in the game and elements of sand animation, the indicators of thinking speed and mobility of nervous processes also improved, but mainly due to a decrease in low and an increase in average values. This is probably due to the peculiarities of cognitive processes in each of the game options, that is, chess involves competition, while sand animation does not imply rivalry.

Similar ratios of indicators were obtained using the methodology for studying the flexibility of thinking (Table 3).

Table 3. Methodology for studying thinking flexibility.

Thinking flexibility	Group											
	A				B				C			
	1		2		1		2		1		2	
	n	%	n	%	n	%	n	%	n	%	n	%
high	51	16.1	143	45.4	66	19.3	151	44.0	61	18.4	135	40.8
average	225	71.4	167	53.0	232	67.6	186	54.2	227	68.6	189	57.1
low	39	12.3	5	1.6	45	13.1	6	1.8	43	13.0	7	2.1
Total	315	100	315	100	343	100	343	100	331	100	331	100
Student's t-test	4.605				4.276				4.000			
p	<0.05				<0.05				<0.05			
Correlation coefficient	1.000				1.000				1.000			

As can be seen from this table, the game of chess had a more significant effect on the development of flexibility of thinking, however, in this test, in contrast to the previous one, the indicators were the best in group A, which was engaged in the classroom learning.

Of interest are the study results of the working memory capacity and attention, presented in Table 4.

Table 4. Methodology for determining the working memory capacity and attention.

Indicator	Level	Group											
		A				B				C			
		1		2		1		2		1		2	
	n	%	n	%	n	%	n	%	n	%	n	%	
Working memory capacity	high	68	21.6	157	49.8	73	21.3	181	52.7	69	20.8	145	43.8
	average	213	67.6	149	47.3	234	68.2	152	44.3	225	68.0	168	50.8
	low	34	10.8	9	2.9	36	10.5	10	2.9	37	11.2	18	5.4
Attention	high	57	18.1	153	48.6	62	18.1	179	52.2	60	18.1	141	42.6
	average	210	66.7	151	47.9	230	67.1	148	43.1	222	67.1	168	50.8
	low	48	15.2	11	3.5	51	14.8	16	4.7	49	14.8	22	6.6
Total		315	100	315	100	343	100	343	100	331	100	331	100
Student's t-test		4.313				4.806				4.561			
p		<0.05				<0.05				<0.05			
Correlation coefficient		0.486				0.543				0.986			

The increase in both the working memory capacity and attention was mainly influenced by chess lessons, especially in group B, which was engaged in online learning, while in group C, who was

engaged in sand animation, these indicators also improved, but the difference was less pronounced, albeit statistically significant.

However, in the results of the methodology for determining the level of imagination, one can see a slightly different picture (Table 5).

Table 5. Methodology for determining the level of imagination.

The level of imagination	Group											
	A				B				C			
	1		2		1		2		1		2	
	n	%	n	%	n	%	n	%	n	%	n	%
high	61	19.4	187	59.3	65	19.0	201	58.6	63	19.0	212	64.0
average	219	69.5	118	37.5	240	70.0	133	38.8	231	70.0	114	34.4
low	35	11.1	10	3.2	38	11.0	9	2.6	37	11.2	5	1.5
Total	315	100	315	100	343	100	343	100	331	100	331	100
Student's t-test	4.910				5.416				6.179			
p	<0.05				<0.05				<0.05			
Correlation coefficient	0.500				0.500				0.500			

The results of this methodology indicate that sand animation contributed more to the development of imagination than playing chess. It can be assumed that the execution of creative tasks in sand animation required a higher level of abstraction, the creation of new images, which contributed to greater imagination training, while in chess it was required to quickly solve a specific problem, a well-defined situation. Thus, playing chess more influenced the development of such cognitive processes as memory and attention, while sand animation - imagination.

Embedded Figures Test (EFT) (Table 6) allows one to determine what a person is more oriented towards in making decisions - on the knowledge and experience (field dependence) or on external reference points that are in conflict with experience (field independence).

Table 6. Embedded Figures Test (EFT).

Indicator	Group											
	A				B				C			
	1		2		1		2		1		2	
	n	%	n	%	n	%	n	%	n	%	n	%
field dependence	202	64.1	198	62.9	225	65.6	226	65.9	217	65.6	105	31.7
field independence	113	35.9	117	37.1	118	34.4	117	34.1	114	34.4	226	68.3
Total	315	100	315	100	343	100	343	100	331	100	331	100
Student's t-test	1.000				1.000				3.200			
p	=0.325				=0.325				<0.05			
Correlation coefficient	1.000				1.000				0.500			

Interestingly, the initial predominance of field dependence in groups A and B, who played chess, remained the same after the training sessions, while in group C, which was engaged in sand animation, the ratio of field dependence and field independence changed, the parameters seemed to “swap places”. Such results can be explained by the fact that in chess, players remember the previous games, the most successful combinations, and use them with success in the future. Sand animation, on the other hand, requires a new solution every time, not like the previous ones. Therefore, the respondents of group C after undergoing the training became more field independent, while in groups A and B the indicators for this test changed insignificantly, and their ratio actually remained the same.

It is of interest to study the influence of a game on an individual's creative potential, its styles, and implementation strategies (Table 7).

Table 7. Methods for researching the creative potential of a person.

Style	Strategy	Group											
		A				B				C			
		1		2		1		2		1		2	
		n	%	n	%	n	%	n	%	n	%	n	%
integral	theoretical	21	6.7	48	15.2	24	7.0	55	16.0	22	6.6	51	15.4
	activity-oriented	28	8.9	53	16.8	35	10.2	69	20.1	31	9.4	67	20.0
differential	theoretical	74	23.5	78	24.8	86	25.1	92	26.8	85	25.7	62	18.8
	activity-oriented	87	27.6	69	21.9	91	26.5	66	19.2	89	26.9	75	22.7
	emotional	105	33.3	67	21.3	107	31.2	61	17.7	104	31.4	76	23.0
Total		315	100	315	100	343	100	343	100	331	100	331	100
Student's t-test		6.731				8.999				6.197			
p		<0.05				<0.05				<0.05			
Correlation coefficient		0.600				0.100				0.900			

Initially, in all three groups of respondents, the differential style of activity predominated, which indicated the predominant use of specific concepts to assess the situation. More often, the emotional-differential style was revealed, in which the situation had an emotional coloring due to the introduction of the plot or the corresponding definitions. Situations were often viewed in dynamics, in action (activity-oriented style). At the end of the study, after passing the training game lessons, there was a significant change in the ratio of styles of creative activity, with an increase in the integral style. This indicates that game affects the development of abstract thinking, which increased almost twofold both in those involved in chess lessons and sand animation. There was no sharp change in the indicators for this method, which can be regarded as a consequence of their relative stability associated with deep personal and psychophysiological characteristics.

The results of a comprehensive study of cognitive style are presented in Table 8.

Table 8. Cognitive style diagnostic technique.

Indicator	Level	Group											
		A				B				C			
		1		2		1		2		1		2	
		n	%	n	%	n	%	n	%	n	%	n	%

The boundaries of curiosity	high	67	21.3	85	27.0	72	21.0	94	27.4	70	21.1	96	29.0
	average	183	58.1	199	63.2	200	58.3	213	62.1	194	58.6	204	61.6
	low	65	20.6	31	9.8	68	19.8	36	10.5	67	20.3	32	9.7
Believing in oneself	high	39	12.4	78	24.8	41	12.0	82	24.0	40	12.1	89	26.9
	average	192	61.0	225	71.4	215	62.7	247	72.0	206	62.2	239	72.2
	low	84	26.7	12	3.8	87	25.4	14	4.0	85	25.7	3	0.9
Constancy	high	55	17.5	64	20.3	59	17.2	63	18.4	55	16.6	57	17.2
	average	219	69.5	229	72.7	242	70.6	249	72.6	236	71.3	236	71.3
	low	41	13.0	22	7.0	42	12.2	21	6.1	40	12.1	38	11.5
Ambitiousness	high	72	22.9	82	26.0	76	22.2	83	24.2	73	22.1	85	25.6
	average	206	65.4	222	70.5	228	66.5	245	71.4	223	67.4	238	72.0
	low	34	10.8	11	3.5	39	11.4	15	4.4	35	10.5	8	2.4
Auditory memory	high	46	14.6	52	16.5	48	14.0	55	16.0	46	13.9	50	15.1
	average	228	72.4	232	73.7	250	72.9	248	72.3	242	73.1	242	73.1
	low	41	1.3	31	9.8	45	13.1	40	11.7	43	13.0	39	11.8
Visual memory	high	48	15.2	69	21.9	50	14.6	72	21.0	52	15.7	84	25.4
	average	215	68.3	223	70.8	242	70.6	246	71.7	227	68.6	235	71.0
	low	52	16.5	23	7.3	51	14.9	25	7.3	52	15.7	12	3.6
Striving for independence	high	78	24.8	84	26.7	83	24.2	87	25.4	80	24.2	85	25.7
	average	206	65.4	208	66.0	226	65.9	232	67.6	219	66.2	226	68.3
	low	31	9.8	23	7.3	34	9.9	24	7.0	32	9.7	20	6.0
Ability to abstract	high	39	12.4	56	17.8	41	12.0	69	20.2	38	11.5	77	23.3
	average	229	72.7	251	79.7	252	73.4	267	77.8	247	74.6	249	75.2
	low	47	14.9	8	2.5	50	14.6	7	2.0	46	13.9	5	1.5
Concentration	high	30	9.5	87	27.6	33	9.6	95	27.8	31	9.4	86	26.0
	average	241	76.5	223	70.8	268	78.1	240	70.0	258	77.9	230	69.5

	low	44	14.	5	1.6	42	12.	8	2.3	42	12.	15	4.5
			0				2				7		
Creativity level	high	62	19.	98	31.	65	19.	102	27.	64	19.	116	35.
			7		1		0		8		4		0
	average	199	63.	211	67.	220	64.	242	70.	212	64.	208	62.
			2		0		0		6		0		8
	low	54	17.	6	1.9	58	17.	9	2.6	55	16.	7	2.1
			1				0				6		
Total		315	100	315	100	343	100	343	100	331	100	331	100
Correlation coefficient			0.750				0.668				0.721		
p			<0.05				<0.05				<0.05		

Games had the least effect on the development of auditory memory; visual memory had a slight change as well. This result is quite logical since the used game techniques did not actively involve the auditory analyzer in the form of intense verbal communication or listening to music. The visual analyzer was used to a greater extent, especially in the process of sand animation (that was reflected in the results), which contributed to some training of visual memory. The rest of the indicators of this technique were influenced more significantly by the games, however, there were some differences between the effects of playing chess and sand animation on cognitive processes. Thus, if the game of chess was more conducive to the development of concentration and constancy, then sand animation - an increase in the level of abstraction, faith in oneself, the boundaries of curiosity and creativity in general.

Information on the successful use of game techniques for the cognitive development and stimulation of creativity, including the use of modern digital technologies (Karahoca et al., 2018), prompted the idea of the current study, in which the authors compared the impact of different educational games on the cognitive and creative processes of students.

As the research results have shown, games contribute to the development of cognitive processes and creative activity of students. Promoting the game to improve memory and attention is an important aspect, as it helps to develop precisely those cognitive aspects that affect the assimilation of educational material. In addition, training one's working memory while playing provides an improvement in the performance of both simple and complex cognitive actions.

The versatility of the manifestation of personal differences between field-dependent and field-independent people affects the success of their professional activities, which for the former is associated with social contacts, and for the latter presupposes high independence in achieving the set goal. Taking into account these features, it was possible to predict that both used games would contribute to the development of field independence of the experiment participants. However, this effect was recorded only when using sand animation, while in groups A and B, who played chess, the ratio of field-dependent and field-independent participants almost did not change after completing the training. This result can be explained by the fact that field-dependent people, in contrast to field-independent ones, are more guided by their knowledge and experience, which in chess is associated with the use of theoretical knowledge and ready-made variants of successful combinations. In sand animation, there were no ready-made standard solutions, the players were freer in their game activities, where they were encouraged to be creative.

The stylistic features of thinking inherent in cognitive styles depend on the personality traits and characteristics of a person's perception (Khalifaeva et al., 2020). The importance of this aspect of

cognitive activity is determined by the duality of cognitive style parameters, which, on the one hand, are a fairly stable individual characteristic of a personality at a certain stage of its development, and on the other hand, reflect the dynamic picture of the educational process, since they largely depend on learning technologies (Khalifaeva et al., 2020). The research has shown that, despite the presence of sufficiently developed cognitive styles among students, games contribute to their development and the integrity of the perception of the world. Thus, the authors conclude that games contribute to ensuring the need for adaptation of students to the educational process and harmonization of their relations with the external and internal world.

It is safe to say that games contribute to the improvement of cognitive processes and the development of the creative abilities of an individual, however, different games are aimed at the development of various cognitive aspects. In addition, a game's influence depends on psychophysiological characteristics and personality factors. Therefore, games, given their effectiveness, should become a mandatory component of the educational process, however, when developing curricula, one should take into account the validity of gaming techniques, their compliance with the goals and objectives of learning, as well as the psychophysiological and personal parameters of students.

The revealed features of the influence of games on cognitive and creative processes can be considered as a pilot study, which showed the prospects of this direction. Thus, further research may focus on the study of age, gender, racial characteristics of games, differences in the impact of team and individual games, and much more.

4. Conclusions

The game is an effective means of intensifying and improving the quality of the educational process for students. The inclusion of playing chess in the educational process, both in classroom and online learning, statistically reliably ($p < 0.05$) improves the indicators of quickness and flexibility of thinking, the volume of working memory and attention, as well as the mobility of nervous processes. When using a sand animation game, these changes are also observed, but they are less pronounced.

Playing chess affects the development of cognitive processes such as memory and attention, while playing based on sand animation requires a higher level of abstraction, which helps to improve the imagination. Considering the importance of developing field independence as an analytical ability associated with making non-standard decisions, it seems necessary to correct the chess tasks taking into account this parameter of cognitive activity.

Playing affects the development of abstract thinking; both chess and sand animation contributed to a statistically significant ($p < 0.05$) twofold increase in abstract thinking, with a predominance of the field independence. Nevertheless, there was no sharp change in the indicators for this method, which can be regarded as a consequence of students' relative stability associated with deep personal and psychophysiological characteristics.

Playing chess to a greater extent contributed to the development of concentration and constancy, and playing based on sand animation increased the level of abstraction, self-confidence, curiosity and creativity in general. In equal measure, games influenced the level of ambition and the desire for independence.

The research has shown that, despite the presence of sufficiently developed cognitive styles among students, play activity contributes to their development and improvement in the direction of integrity

Daniyarova, A., Suad, A., Vecherinina, E., Seluch, M., & Ananishnev, V. (2022). Games for Science Education: Is this technique effective for developing students' creativity and scientific competence? *World Journal on Educational Technology*, 14(1), 14(1), 28-41. <https://doi.org/10.18844/wjet.v14i1.6629>

- the integrity of the perception of the surrounding world, thus ensuring the needs of students' adaptation to the educational process and harmonization of their relations with the external and internal world.

Game activity, given its effectiveness, should become an obligatory component of the educational process, however, when developing curricula, one should take into account the validity of game techniques, their compliance with the goals and objectives of learning, as well as the psychophysiological and personal parameters of students.

The revealed features of the influence of play activity on cognitive and creative processes indicate that this direction is promising and allows outlining vectors for further research aimed at studying age, gender and racial characteristics of play activity, and determining the differences in the impact of team and individual games.

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