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## MODERN TEACHING TECHNOLOGIES СУЧАСНІ ПЕДАГОГІЧНІ ТЕХНОЛОГІЇ

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### THE IMPLEMENTATION OF THE CREATIVE THINKING DEVELOPMENT TECHNOLOGY OF HIGH SCHOOL PUPILS IN THE EXTRACURRICULAR ACTIVITIES: RESULTS OF THE PEDAGOGICAL EXPERIMENT

**O. Ye. Antonova\***, **S. A. Postova\*\***, **S. L. Yatsenko\*\*\***

*The article substantiates the need to create conditions for the formation of students' creative personalities, realization and self-realization of their opportunities and possibilities in the educational process. It is noted that a significant tendency of modern education is its intensification, which primarily implies a reduction in the number of hours for studying subjects, while their content remains unchanged. Thus, it makes impossible for students to master ways and means of solving non-standard creative tasks and objectives. Therefore, the problem of developing and introducing technologies for the development of creative thinking of high school pupils in extracurricular activities is urgent and important.*

*The authors analyzed modern approaches to understanding the concept of "creativity", identified the main components of the creative process, traced the relationship between creativity and thinking. The characteristic features of creative thinking are determined, the features of its development in high school pupils in the process of participation in extracurricular activities are revealed.*

*The state of development of creative thinking of high school pupils, including participants of the III-rd and IV-th stages of the Olympiad in information technologies and research works*

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contest of the Junior Academy of Sciences of Ukraine, including the members of the study groups ("Applied Software" and "Automation of Scientific Research") is analyzed. Insufficient level of students' creative thinking and poor motivation for its development were revealed.

The technology of development of creative thinking of high school pupils during the classes of the "Applied software" study group is offered and described. On the basis of the analysis of the results of the forming stage of the experiment, it is concluded that its influence on the level of high school pupils' basic theoretical knowledge in computer science, practical skills and non-standard IT / CS problem solving skills, as well as the development of algorithmic, systemic and creative thinking.

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**Key words:** creativity, creative thinking, properties of creative thinking, development of creative thinking, extracurricular activities, extracurricular activities in computer science, creative thinking development technology, competencies (practical, creative, social).

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## **ВПРОВАДЖЕННЯ ТЕХНОЛОГІЇ РОЗВИТКУ ТВОРЧОГО МИСЛЕННЯ СТАРШОКЛАСНИКІВ У ПОЗНАВЧАЛЬНІЙ ДІЯЛЬНОСТІ: РЕЗУЛЬТАТИ ПЕДАГОГІЧНОГО ЕКСПЕРИМЕНТУ**

**О. Є. Антонова, С. А. Постова, С. Л. Яценко**

У статті обґрунтовано необхідність створення умов для формування творчої особистості учнів, реалізації її самореалізації їхніх можливостей в освітньому процесі. Зазначено, що суттєвою тенденцією сучасної освіти є її інтенсифікація, що передусім передбачає скорочення кількості годин на вивчення навчальних предметів при незмінності їх змісту. Це, у свою чергу, призводить до неможливості навчання учнів розв'язувати нестандартні, творчі завдання у робочий час. Тому нагальною постає проблема розробки та впровадження технологій розвитку творчого мислення старшокласників у позанавчальній діяльності.

Авторами проаналізовано сучасні підходи до розуміння поняття "творчість", визначено основні складові творчого процесу, простежено взаємозв'язок між творчістю та мисленням. Визначено характерні риси творчого мислення, виявлено особливості його розвитку у старшокласників у процесі позанавчальної діяльності.

Проаналізовано стан розвитку творчого мислення старшокласників, учасників III та IV етапів олімпіади з інформаційних технологій, конкурсу-захисту науково-дослідних робіт МАН та членів гуртків при науково-технічній творчості учнівської молоді "Прикладне ПЗ" та "Автоматизація наукових досліджень". Виявлено недостатній рівень творчого мислення учнів та слабку мотивацію до його розвитку.

Запропоновано та описано технологію розвитку творчого мислення старшокласників на заняттях гуртка "Прикладне програмне забезпечення". На основі аналізу результатів формувального етапу експерименту зроблено висновок про ефективність її впливу на рівень володіння старшокласниками основними теоретичними знаннями з інформатики, практичних умінь та навичок розв'язування нестандартних завдань з інформатики, розвиток алгоритмічного, системного й творчого мислення.

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**Ключові слова:** творчість, творче мислення, риси творчого мислення, розвиток творчого мислення, позанавчальна діяльність, позанавчальна діяльність з інформатики, технологія розвитку творчого мислення старшокласників, компетентності (практичні, творчі, соціальні).

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**Introduction of the issue.** Dynamic development of modern life of the country, as well as informatization of society necessitate the creation of the

conditions for the formation of creative personality of both teacher and student, the realization and self-realization of their opportunities and

possibilities in the educational process. Over the last decade there has been a clear tendency for substantial increase in the number and variety of intellectual and creative competitions, contests, Olympiads, which allows the pupils to fully expand their abilities, outline life prospects, set meaningful multi-level goals and achieve them. However, only the pupil who has developed creative thinking, strong motivation for constant development and self-improvement can demonstrate good results in the mentioned above activities.

Another trend of modern education is its intensification, which implies, in particular, a reduction in the number of academic hours dedicated to a certain subject, however, the content of the educational process must remain of the same quality and quantity with constant improvements and innovations. This leads to the lack of time for students to learn to perform non-standard, creative tasks, to optimize found solutions, and so on. At the same time, pupils get such an opportunity during extracurricular activities. Therefore, the problem of designing, approving and introducing creative thinking development technologies for high school pupils in extracurricular activities is an urgent issue.

**Current state of the issue.** The problem of creativity in pedagogy and psychology has always occupied a prominent place. Thus, it is widely recognized that creative thinking can be considered as "a creative activity that produces a nontrivial (qualitatively new) result" [2].

Modern psychology distinguishes the following components of the creative process: the formulation of a question that requires a creative answer – the ability to see the problem; mobilizing the necessary knowledge to formulate a preliminary hypothesis to determine ways and means to solve the problem;

special observations and experiments, their generalization in the form of conclusions and hypotheses; design of thoughts or ways that have arisen in the form of logical, figurative, mathematical, graphic subject structures; checking the social value of a product of creativity. These components are interdependent, closely interconnected and can be merged or separated from each other in time [5].

The process of creativity can be presented in three interrelated stages (S. Sysoieva) [9]: the pupil (child) sets a task and seeks the necessary information; examines tasks from different sides; brings the work started to its logical conclusion. Awareness of the essence of the creative process and its phases allows the teacher to effectively build the educational process, focusing students' attention not on reproductive but on creative activity. Therefore, the question of the relationship between creativity and thinking is important.

According to L. Yermolaieva-Tomina, "thinking and creativity are two processes that are closely intertwined with each other, although they pursue different goals and use different thinking operations. Thinking is about knowing the real world, and creativity is about rebuilding, renewing and improving it" [3]. A. Petrovskiy considers creative thinking as cognitive processes that allows a person to solve problems that cannot be solved by methods already known to mankind [8].

In our opinion, an important indicator of creative thinking is its unpretentiousness, as well as the ability to embrace reality in all its relations and interconnections; transfer knowledge to new conditions and levels; link one object with another; the ability to see structural components of the solid whole; find a non-standard approach to solving standard tasks; etc.

Ye. Zharikov and Ye. Krushelnytskyi give such characteristic features of creative thinking:

1) heuristic – the ability to solve problems that require the discovery of patterns, properties, relationships;

2) creativity – the ability to create new things and new methods;

3) mobility – the ability to move from one related field of science into another, solve complex problems;

4) independence – the ability to withstand the traditional views in science and hinder the acquisition of fundamentally new knowledge;

5) representativeness – the ability to see the prospect of the object under study based on limited information about the subject matter, to predict its future state, to build hypotheses about its past states;

6) systematic – the ability to embrace an object as a whole;

7) rationality – the ability to dialectically deny old systems of knowledge that hinder the qualitative change of science;

8) openness – ability to perceive any ideas;

9) antinomy – the ability to see the unity of opposites or the absence of regularities;

10) ability to generalize material that allows an individual to rise from empirical concreteness to conclusions about common properties [4].

Thus, creative thinking expresses such varieties of human mental activity as productivity, constructiveness, ingenuity and ability to make reasonable predictions. It is strongly connected with logical, algorithmic, systemic, divergent and heuristic types of thinking.

There are several approaches in the national pedagogical science to the concept of "development of creative thinking": according to S. Vitvytska, development of thinking is not a simple change of types and forms of thinking, but their transformation, improvement

in the process of assimilation of more abstract and generalized information [1]. The scholar focuses on the fact that for the teachers the process of development of thinking has the following meanings:

1) to develop all kinds and forms of thinking: practically-effective, visual-figurative, verbal-logical, empirical and theoretical, debatable and intuitive, productive and reproductive – and stimulate their transition from one to another;

2) to form and improve mental operations (analysis, synthesis, comparison, generalization, classification);

3) to develop the following skills and abilities: to distinguish essential properties of objects and to abstract them from irrelevant ones; to find the main connections and relations of things and the world phenomena; make the correct conclusions from the facts and verify them; to prove the truth of their judgments and to refute false assumptions; to reveal the essence of the basic forms of correct inferences; to present the thoughts consistently and evidence-based;

4) to develop the ability to transfer operations and techniques of thinking from one field of knowledge to another; to anticipate the development of phenomena and to make sound conclusions;

5) to stimulate the process of transition from *formal logic-based thinking* to *dialectical logic-based thinking*; to improve the ability to use the laws and requirements of formal and dialectical logic in students' educational and cognitive activities.

Therefore, to develop creative thinking means to develop its components – all kinds and forms of thinking operations, procedures of cognition, logical skills and techniques in the process of mastering the system of scientific knowledge provided by the school curriculum [1].

The main criteria for the development of creative thinking (according to D. Mamediarov) are the ability to: analyze, synthesize, summarize and produce conclusions on data acquired; find interrelations and their impacts; set up tasks, objectives, and review problems; design hypotheses; structure the information received according to the patterns; switch from one idea to another using the current knowledge in order to acquire new experience [7].

To ensure the effective development of pupils' creative thinking, a set of favorable conditions is created during their participation in extracurricular activities, which are an integral part of the educational process. It must be mentioned that extracurricular activities, in their turn, are defined as a form of organization of students' free time, which forms a system of communication-based interaction, a voluntary cognition, which is free from compulsory learning and academic restrictions, limitations and regulations, and is encouraged by cognitive needs and personal interests of pupils [6].

We believe, that high school is the most suitable stage to study computer science for a significant amount of knowledge in multiple subjects is mandatory, as well as the basic computer interaction skills and software peculiarities. Performing creative tasks in computer science implies the obligatory provision of a certain level of independence of students, since creative tasks are not structured, have a cross-curricular nature, and, most importantly, there is a very low probability of successfully completing the creative tasks without proper investigation and preparation, excluding "lucky guess" factor.

**The aim of the article** is to study the state of development of creative thinking of high school pupils and the

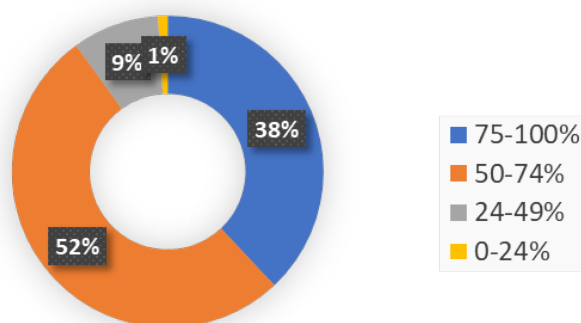
impact of extracurricular activities in computer science on its development.

**Research results and discussion.**

We have conducted a survey among the pupils-participants of the III-rd and IV-th stages of the Olympiad in information technologies, research works contests of the Junior Academy of Sciences of Ukraine and members of extra-curricula circles at the regional center of scientific and technical creativity of pupil youth "Applied Software" and "Automation of scientific researches" (300 individuals). The study was mainly divided into two parts: 2012-2014 – diagnostic section, 2017-2019 – forming section. All stages of the pupils' research works contest were subject to evaluation: extramural evaluation of research paper; major subject testing (mathematics); presentation and public discussion of the research work conducted.

Overall preliminary impression is the following: research papers and experiments conducted by the pupils-participants of Junior Academy of Sciences of Ukraine young researchers' contest (2012-2014 a.y.) indicated quite low level of their scientific inclination and basic knowledge of core subject (mathematics), which implies certain limitations to realization of their creative potential.

Corresponding evaluation of the works, which was carried out on a number of criteria (relevance, theoretical and (or) practical importance of the issue; scientific novelty of the obtained results; systematic and completeness in the disclosure of the topic; research nature of the issue-solving work; expediency and correctness of the used research methods; results, etc.) showed that only 38 % of participants (84 students) reached the high level. At the same time, almost 10 % of participants (20 students) scored less than half of the maximum score (Pic. 1).



Picture 1. Summarized results of the extramural evaluation of pupils' research works of the Junior Academy of Sciences of Ukraine

Research papers presentation and public discussion, which had its own evaluation criteria (the reasonableness of the choice of research topic and its disclosure; author's awareness of the topic material; the degree of author's independence in the process of scientific search and issue investigation; personal contribution of the author to the conducted research; clarity, logic, consistency, concise of the presentation of the research material, etc) indicated that about 42 % of the participants achieved high results. However, almost 20 % of participants scored less than half of the maximum possible score.

Among the typical mistakes of students are the following: technical errors in the design and structure of scientific work; pseudoscience; lack of analysis of similar coding samples (for software products); uncertainty of fundamental difference of the offered software product (its novelty); inappropriate structure of software product / coding (databases, site, etc.); providing only software sample or technical documentation without description of the theoretical part; insufficient knowledge of theoretical material (mathematics, computer science); use of invalid or inappropriate terms and abbreviations (in most cases due to inaccurate translation); the

inability to communicate with other participants, jury members.

Insufficient level of development of creative thinking of high school pupils was also revealed during the analysis of offered students' solutions of the Olympiad (IT) tasks. There was a clear tendency to experience considerable difficulties in the process of undergoing theoretical testing and performing sub-structured practical tasks (dividing it into relevant sub-tasks and establishing cross-curricular relations, defining thematic specification of the task, performing creative objectives, etc.). Thus, almost 50% of participants scored less than half of the maximum possible score according to the proposed criteria.

The next stage of the research was the interviewing of respondents using a specially developed methodology, which consisted of three blocks of questions. The first block allowed to determine the general level of knowledge and skills of the pupils: 75 % of the respondents marked their academic successfulness as "well", 8 % indicated the "excellent" performance during the academic year and only 17 % of individuals chose "satisfactory" option. At the same time, 71 % of students said that they liked the organization of the learning process, but only 14 % confirmed that it facilitates the development of their abilities. This highlights the need to

diversify the forms, methods and means of conducting computer science training.

The second block of the survey consisted of questions that allowed us to determine the level of development of

creative thinking of high school pupils on the scale of expression of qualities (from 0 (absent or at very low level) to 5 (expressed at a high or extremely high level) (table. 1).

Table 1

**The results of determining the level of development of creative thinking of high school pupils**

№	Personality Traits	0	1	2	3	4	5
1.	The need to constantly expand the outlook, cognite the world around, analyze and learn more about him- /her- „Self”	3% (9)	16% (48)	54% (162)	18% (54)	7% (21)	2% (6)
2.	Orientation to search for new titles, ideas, necessity to create his / her own picture of the world	1% (3)	15% (45)	47% (141)	18% (54)	15% (45)	4% (12)
3.	Tendency to analyze facts and events, to form his / her own opinions	0% (0)	16% (48)	47% (141)	18% (54)	15% (45)	4% (12)
4.	The desire to reach the essence of complex problems, discover social and natural phenomena	1% (3)	9% (27)	39% (117)	23% (69)	25% (75)	3% (9)
5.	The desire to achieve significant results in educational activities	0% (0)	3% (9)	10% (30)	23% (69)	49% (147)	15% (45)
6.	Positive emotional well-being while performing educational tasks	2% (6)	15% (45)	18% (54)	39% (117)	20% (60)	6% (18)
7.	The desire to perform creative work, participate in creative activities	0% (0)	15% (45)	46% (138)	17% (51)	13% (39)	9% (27)
8.	Interest in the creative pursuit of new knowledge, facts, patterns	0% (0)	10% (30)	26% (78)	38% (114)	18% (54)	8% (24)
9.	The propensity for creative activity under any circumstances	1% (3)	11% (33)	27% (81)	38% (114)	17% (51)	6% (18)
10.	The desire to achieve new creative results in behavior and any kind of activity	1% (3)	16% (48)	25% (75)	30% (90)	19% (57)	9% (27)

Analyzing the results of the students' answers to this block of questions indicates a low level of creative thinking and poor motivation to improve it.

The third block of questions was aimed at determining the impact of extracurricular activities in computer science on the development of creative thinking of high school pupils (table. 2).

Table 2

**The results of studying the effectiveness of the impact of computer science extracurricular activities on the development of creative thinking of high school pupils**

	Yes	Partially Yes	No
Do you like to participate in computer science (IT) competitions, Olympiads and / or contest of Junior Academy of Sciences of Ukraine?	63% (189)	28% (84)	9% (27)
Are the tasks of IT Olympiad new to you?	35% (105)	47% (141)	18% (54)
Do these tasks have a practical orientation?	24% (72)	61% (183)	15% (45)
Do the tasks offered allow you to be creative?	20% (60)	55% (165)	25% (75)
Do you feel yourself encouraged to gain new IT knowledge by these tasks?	63% (189)	30% (90)	7% (21)
Are there cross-curricular links in these tasks?	58% (174)	39% (117)	3% (9)
Do the olympic tasks contribute to the development of logical thinking?	61% (183)	38% (114)	1% (3)
Do these tasks encourage you to use non-standard ways of solving?	15% (45)	73% (219)	12% (36)
Does solving this type of task help you to increase your self-esteem?	12% (36)	69% (207)	19% (57)
Does the ICT Olympics help you to put your knowledge and skills into practice?	9% (27)	77% (231)	14% (42)
Did you manage to divide the proposed tasks into sub-tasks yourself?	5% (15)	61% (183)	34% (102)
Do you feel yourself encouraged to find new ways and means of solving tasks while participating in the Olympics?	7% (21)	58% (174)	35% (105)



The analysis of the results indicates that the computer science extracurricular activities have insufficient influence on the development of students' creative thinking.

Thus, we concluded that the majority of the surveyed high school pupils had a low level of basic theoretical knowledge in computer science (including IT), a low level of scientific experience, attainment, practical skills and non-standard CS and IT problem solving abilities, together with poorly developed algorithmic, systemic and creative thinking, as well as poor motivation for creative activity and creative thinking development. The results also suggest that a significant proportion of respondents underestimate the impact of extracurricular CS and IT activities on the development of their creative thinking.

According to the data collected and processed, the technology was designed (by S. Postova) for the development of creative thinking of high school pupils, which was introduced at the classes of the "Applied software" study group (circle). This program is aimed at comprehensive preparation of gifted pupils for computer science research, namely, detailed study of various types of modern software, training of youth researches for participation in the CS and IT Olympiads, various tournaments and other intellectual competitions (involving computer science and ICTs). The program can be adapted by other teachers, taking into account the planned number of hours, the peculiarities of the elementary institution's work, etc.

The basic tasks of a study group are to form the following competences:

– cognitive: mastering modern types of software; familiarization with the methodology and means of scientific research in the field of computer

engineering; formation of scientific outlook, modern scientific thinking;

– practical: formation of skills and habits of performing research work, planning and organization of computational and model experiments, processing of results of experimental researches, independent processing of scientific literature, selection, analysis, systematization of material and registration of results of scientific activity;

– creative: development of search, inventive, research, creative activity; technical thinking; formation of skills of independent choice of methods of work, direction of scientific research; ability to navigate the information space, to creatively solve complex scientific problems;

– social: formation of a sustainable interest in scientific activity, creative initiative; development of positive qualities of the emotional-volitional sphere of personality: diligence, perseverance, responsibility, ability to make and defend his / her own decisions; education of students' conscious attitude to future professional activity in the conditions of wide informatization of society.

In the first semester, students are introduced to basic general-purpose software, basic concepts of research activities and methodology of scientific research, learn to properly (as required) design and perform scientific tasks. Each student chooses a topic of scientific research, makes up a plan and schedule, as well as analyzes the sources of information, determines the purpose and main objectives of the research, selects methods and means, prepares scientific activities and submits it for participation in all-Ukrainian research papers contest of Junior Academy of Sciences and other competitions. In the second semester students are introduced to special purpose software, preparing for the tournament and other competitions in

computer science. At this stage, an analysis of the scientific research is also scheduled and expected.

An important aspect of working with pupils is to prepare them to solve IT Olympiad tasks, which is carried out in several stages:

- familiarization with written details of the task and identification of its main thematic issue (including interdisciplinary nature);
- dividing the whole task into smaller components (sub-tasks);
- suggesting ideas for solving a specific sub-task;
- highlighting the main stages of solving a subtask;
- implementation of the elaborated solution in the environment of the chosen applied software environment;
- checking the correctness of the solution and analyzing the result obtained; correcting the resultant solution in case of conflict with the condition or the tasks set by the authors (if necessary).

Complex preparation of students for solving Olympiad tasks in information technology consisted of the following set of steps:

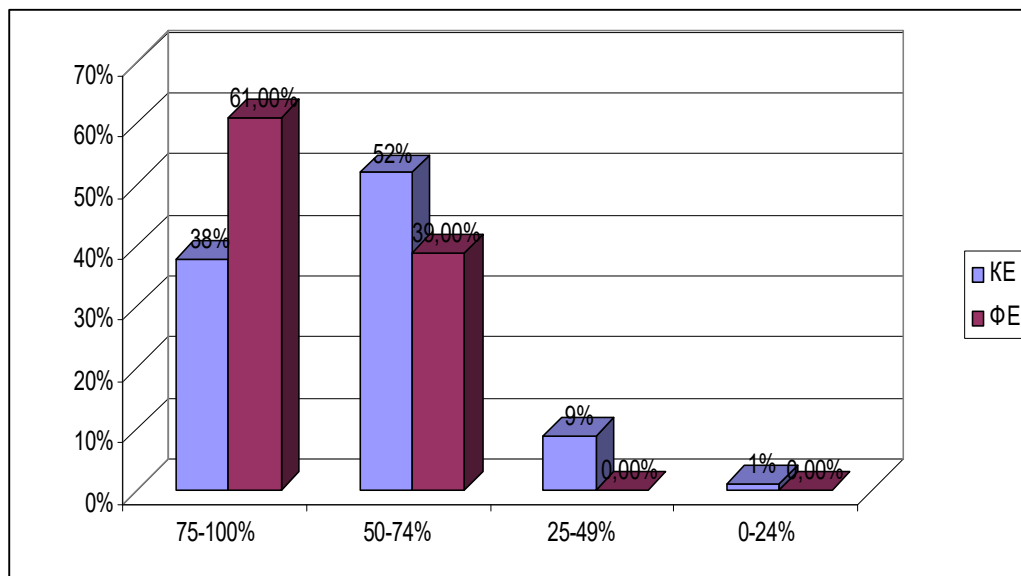
- ✓ substantial theoretical set of knowledge in the spheres of IT / CS / ICT and proper preliminary training;
- ✓ reviewing and analyzing tasks from the previous contests (independently or under the teacher's guidance);
- ✓ solving the tasks from the previous contests (according to the offered scheme if possible);
- ✓ searching for interesting, curious or non-standard IT tasks on the Internet and solving them;

✓ systematic enlargement and update of personal knowledge (IT sphere); expansion of the outlook.

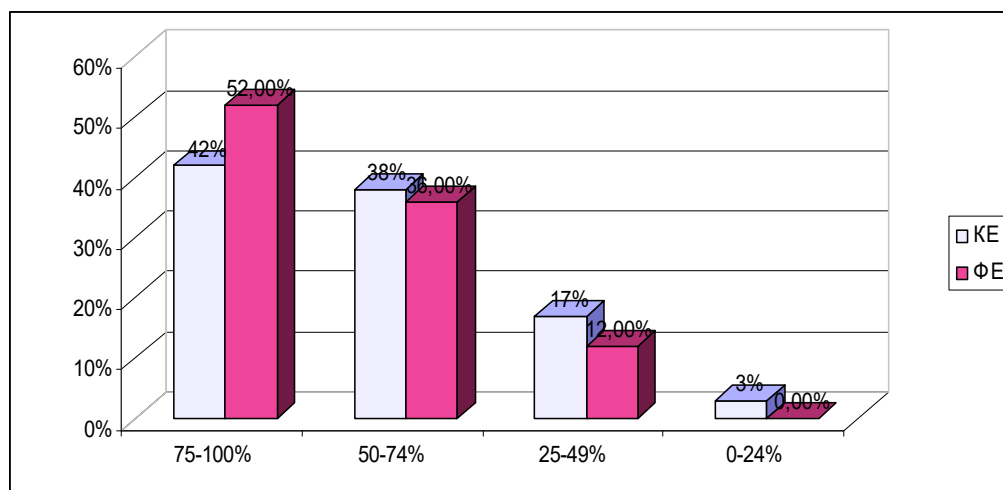
For the purpose of pupils' training for the solution of Olympiad tasks in information technologies we have designed an internet website [sites.google.com/view/zippoint](https://sites.google.com/view/zippoint) with the help of services GOOGLE services, thus, both practical and theoretical sets of tasks from previous contests have been placed there (2 types of tests are presented – using the Google Forms online resource and a portable version for offline individual use, which is developed by EasyQuizzzy).

After the introduction of the described technology, in 2014-2018 a.y. a comparative section of the results of the survey of pupils-participants of the scientific research paper presentation and discussion contest of Junior Academy of Sciences of Ukraine was conducted. The results indicate a significant improvement in the results obtained (pic. 2). Thus, more than 60% of participants (213 individuals) reached a high level, respectively, none of the participants scored less than half of the maximum number of points.

The analysis of the results of the final stage of the experiment showed that more than 50 % of participants (185 pupils) achieved high rates during the presentation and discussion of scientific research papers and only 12 % of participants (43 high school pupils) scored less than half of the maximum number of points (pic. 3). Thus, there is a steady tendency to significantly improve both student outcomes and increase the development of their creative thinking.



Picture 2. Comparison of results of extracurricular stage of evaluation of pupils' scientific research paper (Junior Academy of Sciences of Ukraine) at the ascertaining stage of the experiment and after conducting the formative stage of the experiment



Picture 3. Comparison of the results of the stage of evaluation of pupil's scientific research paper (Junior Academy of Sciences of Ukraine students' at the statement stage of the experiment and after the forming stage of the experiment

**Conclusions and research perspectives.** Thus, the analysis of the obtained results made it possible to conclude that after the application of the technology of development of creative thinking of high school pupils, which was introduced at the classes of "Applied software" study group, the level of high school pupils' basic theoretical knowledge in computer science (including IT) has significantly

improved. Also, there is an increase in the level of scientific knowledge, practical skills and non-standard tasks solving abilities in CS / IT, as well as the tendency for better development of algorithmic, systemic and creative thinking, including motivation for creative activity and development of creative thinking.

The study does not claim to be a definitive response to the problem of

developing the creative thinking of high school pupils in extracurricular activities. The relevance and complexity of its solution requires further theoretical and experimental research in the areas of: improving the content, forms, methods of preparing high school pupils to participate in intellectual competitions and tournaments; diversification of training of CS teachers in the system of postgraduate education for the development of creative thinking of high school pupils during the extracurricular activities; enriching the content and tasks of pupils' pedagogical practice in order to prepare them for the organization of teamwork, etc.

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