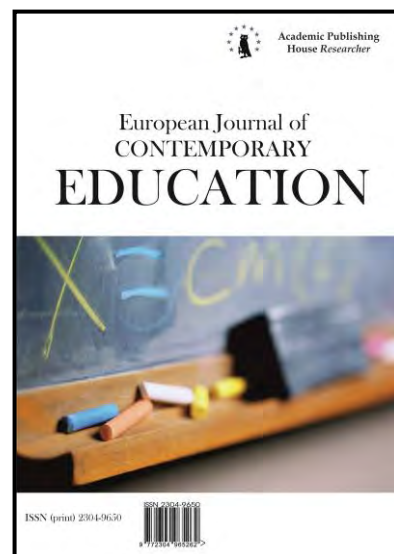




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Formation of Group Creative Thinking When Working with Virtual Walls

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Abstract

The problem to be solved by the research is due to the need to prepare a graduate capable of creative thinking, working in a team, managing changes, projects, teams of people within the modern educational environment, and insufficient degree of development of the methodological base for training specialists of the future that meets these requirements.

The aim of the study is to theoretically substantiate and experimentally test effectiveness of using virtual walls for formation of group creative thinking, as an important skill that corresponds to conditions of uncertainty of the future.

The research methodology is the analysis and generalization of scientific works on the problem of determining the essence of group creative thinking, the virtual wall, clarifying requirements for training of highly qualified specialists of the future. Methods of group interactive learning (demonstration in the distant form of interaction, online discussion, defense of projects, and work on a virtual team wall) are used to enhance cognition, create favorable conditions for creativity when working in a team. The Trello service is a software tool for supporting online collaboration and group creative discovery. The pedagogical experiment is presented on the example of assessing changes in the levels of skills that constitute the essence of group creative thinking.

Research results. The work clarifies the essence of the concept “group creative thinking” and describes the directions of group work on a virtual wall, which is most effective when forming it. The authors formulated the conditions under which the group activity on a virtual wall contributes to formation of group creative thinking: awareness of the meaning and motives of activity; the need for self-expression, active participation in the discussion, etc. Specific materials are proposed to

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improve the quality of education by means of supporting students' group activities, focused on their creative development and preparation for future professional activities.

In the conclusion findings that confirm the inclusion of group activities on a virtual team wall in the training of specialists of the future contributes to formation of skills and abilities that make up the essence of group creative thinking are given.

Keywords: creativity, insight, group activity, team wall, team, online learning, interaction.

1. Introduction

1.1. The relevance of the problem

The relevance of the presented study is due to the following factors:

1. The ability for creative thinking, insight and discovery, as it was noted in the studies of the international program for the assessment of educational achievements (PISA project), is the basis for development of spheres of culture: science, technology, philosophy, art and other areas (Avdeenko et al., 2019). Socio-economic progress is directly dependent on the emergence of innovative ideas, on the creation of new knowledge and technologies.

2. Training of a creative specialist who can work on solving a problem in a team, is open to accepting a new theoretical fact and its immediate application in practice, uses modern digital means in his/her intellectual activity is an urgent direction of modernizing education.

3. The ability to work in a team, implementation of group research activities in the context of the spread of COVID-19, self-isolation of developers and introduction of the distant interaction mode has intensified development of digital technologies that support virtual communication and collaboration.

B. Sánchez-Barbero, J. M. Chamoso, S. Vicente, J. Rosales convincingly prove that the ability to creative, innovative thinking is more or less inherent in every person (Sánchez-Barbero et al., 2020). Including in training the practice of developing mobile applications (Soboleva, Perevozchikova, 2019), 3D models (Aljarrah, 2020), storytelling (Smyrniou et al., 2020), comics (Permata et al., 2020), musical accompaniment (Fritz et al., 2020), decorative type design (Dolgikh, Dolgikh, 2019), design competitions (Abrahamson et al., 2020). is proposed for supporting creativity and imagination. Researchers propose holistic methodological developments that detail the organization of group learning activities, teamwork and collaboration in the digital educational environment (Abdullah et al., 2021). At the same time, studies devoted to development of group creative thinking by means of modern information software tools are single (Plotnikov, Volkova, 2019). For the most part, they are devoted to the brainstorming technology implemented in the traditional classroom-lesson system (Parker et al., 2017).

However, the changed sanitary and epidemiological conditions determine for the in-demand specialist of the future the need for the experience of creative team problem solving in the distant mode and digital virtual space. The effectiveness of such activities depends on the quality of the following components: teamwork experience, digital tools for virtual collaborative search, formation of group creative thinking.

For developing creative thinking (of an individual and a group) within the digital educational space, obtaining collaboration skills, increasing information literacy and the quality of education, a relatively new and effective cloud services, in terms of functionality, is a virtual sticker board. An interactive cloud application, as noted by A. H. Abdullah et al., allows maximizing all didactic opportunities that digital technologies provide for training highly qualified specialists for group research work in the distant form and in the face of uncertainty of the future (Abdullah et al., 2021).

For such cloud services in foreign scientific and methodological literature various terms are used: "wall for collaboration", "virtual board", "canvas for collaboration", "sticker online board", etc. Further, for the sake of consistency of terminology, we will call this interactive cloud service a "virtual team wall".

Thus, there is a practical need of: changes in the organization of educational activities by the teacher, focused on development of group creative thinking in professionals of the future; active use of virtual cloud services in collaboration for integrating sustainable development goals into real projects, promoting them in science and industry.

1.2. Goals and objectives of the research

The purpose of the study is determined from the need to realize possibilities of virtual team walls when training highly qualified specialists and forming group creative thinking, as an important skill that meets the requirements and challenges of the future.

Research objectives:

- to clarify the essence of the concept "group creative thinking" in the context of the digitalization of society and the current sanitary and epidemiological situation;
- substantiate the potential of virtual team walls for formation of group creative thinking;
- to formulate principles, directions of support by the mentor of the research activities of students with the help of the virtual team wall;
- to introduce a system for work on the virtual team wall;
- to experimentally confirm effectiveness of work the virtual team wall for formation of skills and abilities that form the basis of group creative thinking.

2. Relevance

2.1. Literature review

2.1.1. Analysis of Russian scientific and pedagogical literature

The use of cloud services, virtual tools and technologies in education is a relevant direction in development of the modern educational (Soboleva et al., 2020). To confirm the objective need for formation of skills of group creative thinking in graduates of the digital school by means of interactive resources, the authors analyzed, firstly, fundamental works devoted to defining the **essence of the concepts of "creative thinking", "group activity", "digital technology"**; secondly, scientific researches aimed at identifying the didactic potential of online services, software and hardware for teaching and learning.

The ability for creative thinking, insight and discovery is the basis for development of all spheres of human culture: science, technology, philosophy, art, humanities and other areas (Avdeenko et al., 2019). Today, as never before, both social development and development of material and spiritual culture, development of production depend on the emergence of innovative ideas, on the creation of new knowledge and new technologies (Soboleva, Perevozchikova, 2019). The ability to think creatively is based on knowledge and experience and, therefore, can be the subject of purposeful formation (Dolgikh, Dolgikh, 2019). In the work of M.N. Dolgikh, N.N. Dolgikh, a detailed analysis of the currently available researches on the problem of concretizing the concept of "creative thinking" is carried out. When summarizing the authors substantiate that the habit of "creatively acting and thinking will help graduates achieve better results in transforming the surrounding reality", effectively and competently respond to the challenges of civilization.

According to M.V. Plotnikov, E.V. Volkov, group thinking is a psychological feature that arises in a team of people, within which conformism or a desire for social harmony leads to incorrect or irrational decision-making (Plotnikov, Volkova, 2019). S.M. Maltseva et al. highlight both positive and negative aspects of this phenomenon (Maltseva et al., 2019). The positive is that in a social group with one team view of things, it is easier to make a decision. The negative side of group thinking is that most often its formation occurs during formation of the personality, that is, during acquiring basic general education (compulsory).

Solving the problem of researching creative thinking involves identifying a set of individual characteristics of thinking, qualities of the mind, on which the ease of mastering new knowledge, the breadth of transfer, and the application of this knowledge in practice depend. As such basic personality traits, which form the basis of creative thinking, E.V. Kharunzheva et al. distinguish: the originality of judgments; the ability to receive answers that differ from the usual; "susceptibility" to the problem, its unusual solution; fluency of the thought; the ability to find new, unusual functions of the answer or part of it; the speed and smoothness of the appearance of unusual (Kharunzheva et al., 2020). The ability to think outside the box and generate interesting ideas helps not only in a career, but also in solving everyday issues (Bushmeleva et al., 2020). According to E.V. Soboleva et al., the use of digital technologies should support receiving feedback, analyzing results of activities (including group ones), work of all participants in the interaction (Soboleva et al., 2020). This requirement is introduced by the authors because the active use of

virtual interactive services (LearningApps, mind maps, online tests, and memory cards) is aimed at improving the quality of learning due to the emotional attractiveness of the tools themselves. At the same time, the strength of the assimilation of fundamental theoretical facts, gaining experience in solving socially significant problems and formation of basic personality traits fade into the background. Moreover, collaboration in the virtual environment makes it possible to develop soft skills that are most in demand in society: communication skills, self-management and effective thinking skills, experience in change management, etc. (Kharunzheva et al., 2020). M.V. Ivshin, S.A. Yurkov substantiate that in the process of team development of stocker boards, additional conditions for development of creativity, curiosity, and important professional competences are created (Ivshin, Yurkov, 2020). They also clarify that there are objective methodological difficulties, which are expressed in the need to implement capabilities of virtual resources for formation of these qualities and competences.

Thus, due to the fact that formation of group creative thinking of a highly qualified and competitive specialist is a priority of the modern educational (*Pasport natsionalnoy...*), there is an objective need to realize the didactic potential of interactive cloud services (including virtual boards for teamwork) for development of skills and abilities that determine the essence of the corresponding thought process.

2.1.2. Analysis of foreign studies

Analytical work in this part of the study was also carried out in two directions. Within the first direction the works devoted to the identification of the didactic potential of virtual walls were studied. Important conclusions in this regard were formulated by M. Hamada, M. Hassan. Researchers note that the use of interactive technologies to support independence and creativity of students is a trend in global educational practice (Hamada, Hassan, 2017). E.J. Kang highlights the tools of digital applications for organizing assessment of students' achievement using the example of virtual testing systems (Kang, 2020). In the course of the research, they manage to collect facts proving that communication supported by online resources contributes to an increase in cognitive activity, intensifies the educational process.

B.S. Palupi, S. Subiyantoro, R. Triyanto consider the functionality of virtual walls for organizing teaching using flip class technology in various learning formats (Palupi et al., 2020). They substantiate the fact that development of a system of tasks that will guide students along the path of cognition in the virtual space should be designed taking into account specifics of e-learning, principles of didactics and according to exact assessment criteria.

R. Salas-Rueda, J. Ramírez-Ortega, A. Eslava-Cervantes believe that resources of virtual team walls allow creating additional conditions for development of thinking (Salas-Rueda et al., 2021). Researchers argue that for students to gain experience of productive group participation when developing evaluating and improving ideas aimed at obtaining new knowledge and/or effective solutions, virtual team walls have a significant didactic potential. Within the second direction, when working with literature, studies devoted to the essence of the phenomena of "group thinking", "creative thinking" and the problems of forming the corresponding personality traits in modern society were analyzed. In particular, H. Kapoor, J.C. Kaufman, note that one of the challenges for the new educational space that determines activities of the person, individual organizations and entire states is the spread of COVID-19 (Kapoor, Kaufman, 2020). The changed circumstances contributed to the emergence of original ideas, the search for non-standard solutions for important socially significant problems (distant work, limited resources, isolation, etc.). B. Sánchez-Barbero, J.M. Chamoso, S. Vicente, J. Rosales argue that the process of learning to search for non-standard solutions should begin at school and should be built on the basis of interactive means of interaction (Sánchez-Barbero et al., 2020). Organization of appropriate cognitive activities supports development of cooperation skills, creativity, and independent reasoning (Rudyshyn et al., 2020). S.F. Permata, S. Nikmah, H. Kuswanto, R. Wardani propose to use media comics in mathematical education for development of creative thinking (Permata et al., 2020). A. Aljarrah complements their research, developing ideas for the use of innovative pedagogical technologies in teaching mathematics to form team creative thinking (Aljarrah, 2020). Group work in the lesson is necessary to maximize the effect of individual efforts of the participants to achieve the goal.

Innovative methodological developments are presented by the team of authors Z. Smyrniou, E. Georgakopoulou, S. Sotiriou. They contain materials for development of creativity, originality of

thinking through the use of digital means for writing stories (Smyrniou et al., 2020). Scientists prove through experiment that the use of graphics, animation, virtual services supports the study of theoretical material through interactive immersion into the problem. Interactive interaction develops imagination, the ability to empathize, and involvement. The design of the story contributes to formation of artistic and aesthetic skills.

In the course of the analysis of the literature it was revealed that the solution of many socio-economic problems is based on the ability of students to sympathize, feel empathy for the needs of others, as well as identify and assess these needs, identify options for development of the problem and put forward constructive ideas, offer innovative and at the same time functional actions. Development of appropriate personality traits can be the result of both individual and group efforts (Irwansyah, Hardiah, 2020). Therefore, studies aimed at identifying and developing means that contribute to development of group creative thinking are of particular interest in pedagogy and informatization of education.

So, to support the teacher's activities for development of group creative thinking in students, it is proposed to use mobile applications, cyber-physical systems, engineering prototypes, educational projects by means of innovative technologies. Cloud technology for creation of virtual team walls is reasonably noted as one of them.

It is the use of virtual team walls that is, firstly, a tool for searching and processing information, discovering a new idea, making a socially significant decision; secondly, an important condition for formation of future specialists' skills and abilities that form the basis of group creative thinking.

3. Materials and methods

3.1. Theoretical and empirical methods

The following methods were used in the study: theoretical analysis and generalization of scientific literature on formation of creative thinking of an individual and a group, using virtual walls in teaching, the potential of teamwork practice to prepare the professionals of the future. The system-activity approach is implemented when the mentor plans stages of group work, organization of information interaction with the virtual team wall, formulation of educational problems and search for a team solution, at the stage of discussion of the results and reflection.

Methods of group interactive learning (brainstorming, discussion, defense of projects, and work on a virtual team wall) are used to enhance cognition, create favorable conditions for creativity and insight. The demonstration method allows to study functionality of an interactive service online, to form a general idea of rules for working on a virtual team wall. The method of frontal laboratory work is used at the stage of obtaining the skills and abilities of information interaction with a virtual team wall when solving specific educational problems. The method of **independent laboratory work supports organization of students' research activities.**

Empirical methods (observation, analysis of the results of work on an educational problem using a virtual team wall) were used to obtain relevant information about formation of skills and abilities that form the basis of group creative thinking. These methods made it possible to obtain information about real qualitative changes in the students' knowledge, curiosity, imagination, visual self-expression, self-confidence, and focus on achieving the goal.

The Trello service is used as a software tool to support online collaboration and group creative discovery. The main didactic advantages of Trello: intuitive interface; almost unlimited free access; ease of use and possibility to integrate with other software environments for distant work. Trello is used by experiment participants to study the technology of a graphic editor on the example of Paint3D. At the stage of statistical processing, the χ^2 (chi-square) Pearson test was used.

3.2. The base of research

Assessment of effectiveness of students' educational and cognitive activities in development and use of virtual team walls for formation of skills that constitute the essence of group creative thinking, was carried out in the course of the pedagogical experiment.

As part of the experiment, a systematic educational work was organized in the graphic editor to study various objects, to obtain qualitatively new knowledge. Virtual team walls were used at all stages of cognitive activity (from goal-setting, choice of means and methods of action, implementation of the intended goal and set tasks, to the analysis and assessment of the obtained

result). The main goal of the experiment was to test the didactic potential of virtual team walls for development of group creative thinking, professional skills in the field of innovative e-learning technologies.

To use virtual team walls as tools for searching and processing information, discovering a new idea, making a socially significant decision, 66 seventh grade students studying at gymnasium №2 in Kirovo-Chepetsk, the Kirov region, were involved. The average age of the respondents was 14 (58 % of girls and 42 % of boys).

To ensure conditions for group homogeneity, when working online and organizing creative activities, one and the same teacher gave lessons to all students. Development of virtual team walls was carried out in the same classrooms, on the same hardware and software. To carry out control activities, the authors developed test tasks. All questions comply with the requirements of the current state federal educational standards.

3.3. Stages of research

The research was carried out in three stages.

At the preparatory stage of the experiment, a list of criteria for formation of group creative thinking was selected, which were subsequently assessed: ease, fluency, flexibility, originality, degree of development. Then the tasks corresponding to this set were developed, they were the basis for the entry test activity. The tasks were carried out in mini-groups of three people, which were formed according to the free will of the participants in the experiment. Based on the selected criteria, educational tasks for the technology of processing graphic images were formulated. All questions and tasks were developed by the authors in accordance with the requirements of state federal educational standards.

As a result of the control event, the participant of the experiment (exactly as a member of the group) could score from 0 to 14 points. As a result of the entrance control testing, almost the same initial level of preparedness of students-participants in the pedagogical experiment was revealed. We can consider them as a total sample of 66 people. Then the participants were divided into groups (33 in the experimental group and 33 in the control group) in order to ensure the presence in each group of the same skills and personality traits that form the basis of group creative thinking, their equal distribution. Characterizing the sample, we note that in the experimental group there were 58 % of girls and 42 % of boys.

The second stage was devoted to determination of principles, directions of support by the mentor of the research activities of students in solving **the educational problem using the “virtual team wall”**. **A methodological system for work on virtual team walls was developed, highlighting the skills and abilities that are significant for formation of group creative thinking.**

The third stage of the research was connected with organization of students' educational and **cognitive activities when studying theory and doing practical tasks on the topic “Computer graphics. Graphic editor”**. To ensure conditions for group homogeneity, one and the same teacher used the Paint3D environment when working with computer graphics throughout the experiment. **The educator held an “introductory meeting” with all members of the experimental group to teach using Trello virtual wall tools and principles.**

4. Results

4.1. Clarification of the essence of basic concepts

The following scientific position was taken as the basis: the basis of creative thinking is the free play of the mind, a "flash", and an insight, which turns into the creative discovery of an individual.

We will consider group thinking as a psychological feature that arises in a team and manifests itself in thoughts, words and actions of each participant. It takes time, team discussion and the mentor's competent methodological guidance for a new idea to be accepted by the group, used when solving a problem. Criteria for formation of group creative thinking are: ease of understanding the problem; fluency when highlighting all kinds of connections and manifestations; flexibility when abandoning the old and making a new decision; originality of the idea; degree of development (detailing the constituent parts of the object under study).

Group creative thinking is a socio-psychological phenomenon, which consists in the following: a properly motivated social group, with a certain organization of its work, which is capable of intellectual breakthroughs that cannot be provided by individual creative thinking.

Further, the essence of the concept of “group creative thinking” was concretized in the context of the system-activity approach, implemented by means of technology for processing graphic images and a virtual team board. In the presented study, the virtual team wall is the **environment in which all members of the group “are” and interact.**

Group creative thinking when working on a virtual team wall is used in the classroom to study the initial object of cognition (obtaining information, processing it, presenting it in a certain way for further study); experiences of the stage of team insight; reaching a new level of the creative activity; to assess the result obtained from the point of view of its use in qualitatively different conditions.

4.2. The educational activity when developing and creating the content of virtual team walls

The Trello software tool (<https://trello.com/>) was chosen to form skills and abilities that make up the essence of group creative thinking by means of interactive technologies in team activities. The tools of this service allow to create teams when training, teams for hobbies, in time management. Teams allow virtual walls and participants to be brought together in one digital educational space. The activities of the mentor when using virtual team walls in the study of graphic image processing technology include the following stages (didactic component):

1) the use of functionality of the virtual board to systematize fundamental theoretical information (the concept of computer graphics, purpose, classification), historical facts, recent discoveries;

2) presentation of a system of educational tasks and mini-projects for researches. Moreover, each team member has the opportunity to upload his/her solution, express opinion, add comment;

3) formulation of a series of questions/tasks for control;

4) tracking the progress of tasks (activity indicating the latest changes, date of execution);

5) assessing activities of each participant and the group (using the calendar, user fields, lists and tags, search and voting functions);

6) visualization of results of work and preparation for the oral defense of projects (the calendar allows to structure the sequence of actions; each stage of the work is placed in the **description of the card; a wall element can “fade” if the information becomes irrelevant; you can easily switch between different cloud applications; when discussing, everyone gets quick access to all wall materials).**

One of the research projects that was implemented using virtual team walls in the course of studying a graphic editor was the project "Smart Home". Statement of the socio-economic problem. In the modern world, any person strives to make his/her home more functional, comfortable and safe. Indeed, returning home after a hard day at work, anyone wants to feel protected and relax. Imagine that you come home, sit on the sofa to relax and watch your favorite movie or program, but suddenly you notice that the TV remote control is not nearby. However, you are already very comfortable on the sofa, covered with a warm blanket. You don't want to get up and look for the remote control at all.

Or a situation: you turned on your favorite movie and suddenly you had to go into another room. You don't want to miss the most interesting or to stop the film at the most interesting place. Can sound follow you? Is this a dream or a reality?

If you assess a house from the side of security? You sleep at night in your bedroom, and a pipe bursts in the bathroom. You sleep soundly, you hear nothing. The water runs down the ceiling of the neighbors, who begin to knock on the doors of the apartment. Water is everywhere. Could this be avoided? Of course, all this is no longer a dream, but a reality. Such a system is embodied in the work of a smart home. You can explore other possibilities of a smart home by following the link: <https://domoticzfaq.ru/principle-work-smart-home/>

The first task for the group: to select other information materials on the project topic; identify the most important and useful functions for each team member.

Study of the theory of graphic processing technology. It is assumed that in the 5th grade, students can work with computer graphics in Paint, have a general idea of its purpose. Theoretical facts for this level of study: determination of graphic image processing technology, graphic editor, classification of computer graphics (by area of use, by way of presentation in computer memory), basic functionality of the technology. Further, using Paint 3D as an example, the functionality was

refined for specific tools and interface. The organization of the relevant activities of the mini-groups is supported by a specially developed instruction.

The second task for the group: to study the interface of the software environment. Step 1. In the **“Start” menu or using the search**, start the Paint 3D program. Display the results of the group work on the virtual wall.

Step 2. Study the basic functionality of the program. Add a description card on the virtual team wall. For example, in the course of team work, the mini-group has a list of cards:

Card №1. In the middle of the program screen there is a working area where all objects are created. The working area can have a two-dimensional and three-dimensional representation. The change of these two modes is carried out with the help of the **“3D view” button in the upper menu of the program.** Next to the 3D view button there is a slider for adjusting the scale.

Card №2. The menu which is at the top of the program window has the following sections (from left to right in order): brushes, 2D and 3D shapes, stickers, text, etc.

1. Brushes: after opening this menu, you can choose a tool for drawing, line thickness, transparency, color and texture. In creative search, the brush and its settings were studied, the differences and features of the work were described (photos of the screen were taken and saved on the virtual wall).

2. 2D shapes: the section provides the ability to create lines by several points and flat shapes. While creative working, 2D shapes were created. An additional menu and the ability to "Create a three-dimensional object" were used. Questions which members asked in the virtual wall comments: What's going on? What is this function for?

3. "3D Shapes": the section allows inserting both ready-made three-dimensional shapes and creating them. The tool "3D Sketch" was used. The color and texture of the shape was changed. Group creativity was manifested when participants, using the "3D Sketch" function, created their own model, chose color and additional effects for it. The result was also on the virtual team wall.

4. Stickers: This section has several subsections to make the shapes more realistic. A smile, **eyes to the subject can be added. In the “Textures” subsection, it is convenient to choose from the proposed realistic coloring for the object, load any custom texture.**

5. Text: allows adding text inserts to objects.

6. Library of three-dimensional objects: the possibility to download from the Internet various models, which are not originally in the software environment.

The third task for the group: using available (ready-made or independently found) information sources, own ideas about the smart home and its innovative possibilities in the future develop and implement an appropriate project. In the following cards, the group members planned activities, assigned responsibilities, worked with the model.

Thus, a variant of the use of virtual team walls for formation of group creative thinking of students is described. An obligatory element is team activities to solve a socially significant problem (project) of a research nature, supported by interactive online technologies. The project involves not only the team implementation of students' activities in the environment of the graphic editor, but also the visualization of all stages, including the result, on a virtual team wall. Although the experiment is presented for image processing technology, similar teamwork can be organized and carried out for various topics and subjects of the digital school. Interdisciplinary projects and competitions are possible. It is this synthesis of engineering and technical practice in the software environment and the didactic component (in accordance with the described areas of pedagogical support) that is maximally focused on formation of group creative thinking. When describing the work of the mentor, we identified specific tools of the virtual wall, the use of which contributes to development of required qualities of both the personality and the group as a whole.

When performing frontal and independent laboratory work, students applied skills and abilities that form the basis of creative thinking, as follows:

–for memorizing (concepts, theoretical facts, tools of the software environment, methods of manipulation and functionality);

–for understanding (at the scientific-theoretical, practical, methodological level);

–for using (when working in the graphical editor environment and creating the content on a virtual team wall);

–for analysing (the results of own activities and work of other users with the virtual service);

–for assessing information, sources of information, software, the possibilities of using the obtained technical and creative results;

–for supporting creative inspiration, obtaining an original idea of a solution in order to test it in practice.

When working on a virtual team wall, four directions of online interaction were implemented: “participant – the whole group”, “participant – participant”, “participant – virtual wall”, “virtual wall – group”.

The resources of virtual walls support the work of the team at the stages of presenting a system of educational tasks and mini-projects for research, formulating a series of questions/tasks for control; tracking the progress of tasks; assessing the work of each participant and the group; visualizing of results and preparing for oral presentation of projects.

4.3. Experimental assessment

4.3.1. The ascertaining stage of the experiment

At the first stage of the experiment, to assess the entry conditions, materials of specially organized testing were used, taking into account the priorities of the digital society, the competence of the atlas of new professions. All questions and tasks were developed by the authors in accordance with the requirements of state federal educational standards.

Task 1 (maximum 2 points). From the list of presented software tools, select those that best suit the goals and purpose of using graphic image processing technology.

Task 2. Using the experience of searching on a computer for files with the extension "jpg" created last month **and containing the symbol “s” in the file name, organize the search according to** the following criteria:

2.1 (maximum 1 point). The file name starts with the character "a", the file was created last year and has the extension "bmp".

2.2 (maximum 2 points). The file name contains exactly 7 characters.

For the second task each group member could get 3 points.

Task 3. Using the experience of constructing a graphic image of one electric train carriage, assemble the train. For completing the third task, each group member could receive maximum 4 points.

Hint 1 (maximum 3 points). The train must include a carriage for the driver. The finished image is presented on paper.

Hint 2 (maximum 4 points). List links to information resources, where the description of various electric trains is presented.

Task 4. Analyze information sources on the research problem and develop a graphic model of the interior item. For completing task 4 each member of the group could receive maximum 5 points.

4.1 (maximum 4 points). Information sources for analysis are selected by the mentor.

4.2 (maximum 5 points). The group is independent in finding information sources and working with them.

Thus, according to the results of the control event, the participant of the experiment (as a group member) could score from 0 to 14 points. The marks were given as follows: “excellent”, when the student scored 12 points or more; “good” if the number of points was from 9 to 11 points inclusive; “satisfactory” for the interval 5 to 8 inclusive. In all other cases, the student got “unsatisfactory”. The mark “excellent” corresponds to a high level of group creative thinking, “good” and “satisfactory” – to average, in other cases the level was defined as low.

It was possible to collect experimental data on 66 students studying in the seventh grades of the gymnasium. As a result of the entry control event, almost the same initial level of preparedness of students-participants in the pedagogical experiment was revealed. We can consider them as a total sample of 66 people. The experimental (33 students) and control (33 students) groups were formed. Characterizing the sample, we note that in the experimental group there were 58 % of girls and 42 % of boys.

4.3.2. Forming stage of the experiment

At the forming stage of the experiment the teacher analyzed requirements of modern society for preparation of students in a digital school. The provisions of the current state federal educational standards determine that the main task of a modern school is to reveal abilities of each

student, to educate a person ready for life in the high-tech, competitive world. In the new conditions of socio-economic development of Russia, the role of a person's ability to plan and implement life strategy on the basis of an adequate self-assessment of possibilities and conditions for self-realization in society is increasing. Positive and stable motivation for active life of a growing person, desire for achievements in labor and creative activities, striving for success in life on a moral and legal basis is needed.

In connection with the indicated requirements for the level of skills and abilities, most of which constitute the essence of group creative thinking, the following levels were determined.

High level of group creative thinking: the student takes the initiative in distribution of functions in the team for development of a virtual object; suggests using various tools, color effects and demonstrates their effectiveness to achieve the goal by own example; is independent in search for information sources and actively participates in the discussion on the fact of identifying their reliability; is attentive to suggestions of other participants and clearly formulates additional questions for reflection; monitors compliance with the sequence of actions of team work (consistency, integrity, degree of detail); critically assesses the result of own and group activities; independently determines options for improving the virtual model and offers them to the team; when defending the project, quickly responds to comments and questions, supports speakers.

The average level of group creative thinking: the student does not always take the initiative in distribution of functions in the team for development of a virtual object; can use various tools, color effects in practice, but does not tell other team members about them; prefers to use already known and proven information sources; often inattentive to participants' suggestions and wary of their additional questions; monitors compliance with the sequence of actions (consistency, integrity, degree of detail) only in own work; not in all cases critically assesses the result of own and group activities; can independently determine options for improving a virtual model, but prefers not to offer them to the team; when defending the project, reacts to comments and questions with little delays and supports speakers but depending on own emotional state.

Low level of group creative thinking: the student does not show initiative in distribution of functions in the team for development of a virtual object; cannot use tools, color effects in practice without assistance; uses only suggested information sources; is inattentive to proposals of the participants and ignores their additional questions; does not monitor compliance with the sequence of actions (consistency, integrity, degree of detail); cannot critically assess the result of own and group activities; does not think about improving a virtual model; when defending the project is sullen, if there are any comments and questions, shifts the presentation of the teamwork on other speakers.

Further, classes on the study of theory and implementation of practical tasks on the topic **"Computer graphics. Graphics editor"** were given in the control and experimental groups. The educator conducted an **"introductory meeting"** with all members of the experimental group exploring Trello's virtual wall tools and principles. Particular attention was paid to possibilities for organizing team activities (providing access by link and email, team visibility, review of progress, comments). Mini-groups for working in a software environment were formed, the choice of topics for the implementation of the team project was made taking into account cognitive interests, educational achievements and social attitudes.

The students of the experimental group were offered possible topics of projects for development of virtual team walls ("Smart House", "Robot Dog", "Policeman of the Future", etc.), from which they chose those that corresponded to their professional aspirations, cognitive interests, abilities, educational achievements.

For the control group, training was carried out in the traditional form: studying the basic concepts of graphic image processing technology, the interface and functionality of Paint 3D, and performing practical tasks according to instructions. The analysis and discussion of results were an obligatory stage of the work.

4.3.3. Control stage of the experiment

At the fixing stage of the experiment, the test was also carried out. The types of tasks, principles of assessment corresponded to the tasks and the procedure of the entry control event.

The statistical analysis of the reliability of the results of the pedagogical experiment was assessed using the χ^2 (chi-square) Pearsen test.

The following hypotheses were accepted:

H0: the level of formation of group creative thinking in the experimental group is statistically equal to the level of the control group.

H1: the level of the experimental group is higher than the level of the control group.

The results of the measuring before and after the experiment for the students of the control and experimental groups are presented in Table 1.

Table 1. The results of the test

Level	The number of tested (people)			
	Experimental group (33 students)		Control group (33 students)	
	Before	After	Before	After
High	2	7	2	3
Average	11	19	12	13
Low	20	7	19	17

In the online resource (<http://medstatistic.ru/calculators/calchit.html>), the values of the criterion are calculated before (χ^2 obs. 1) and after (χ^2 obs. 2) the experiment. For $\alpha = 0.05$ according to the distribution tables χ^2 crit. is 5.99. Thus, we get: $\chi^2_{obs. 1} < \chi^2_{crit.}$ ($0.07 < 5.99$), and $\chi^2_{obs. 2} > \chi^2_{crit.}$ ($6.89 > 5.99$).

Consequently, the shift towards an increase in the level of formation of group creative thinking can be considered not accidental.

5. Discussion

The sample of students was not probabilistic, since the experimental and control groups were formed in such a way as to guarantee the presence in each group of the same skills and personality traits that form the basis of group creative thinking, their similar distribution. For diagnostics the results of the entry control event were taken into account.

The selection of participants for the experiment and the sample size are justified by the specifics of the study: mastering the technology for processing graphic images and implementing its capabilities in 2D and 3D projections involves an in-depth study of certain topics of the school computer science course. Throughout the experiment, creative activity in the Paint 3D environment was carried out by the same teacher, using the same software in special classrooms.

In general, the dynamics of values by levels indicates a qualitative improvement in learning indicators and formation of the monitored personality traits in the experimental group (see Figure 1).

The quantitative analysis of the above results makes it possible to conclude that after finishing the experiment, 21 % of the students in the experimental group had a high level of indicators showing the degree of development of group creative thinking (7 students out of 33), while initially this percentage was 6 % (2 participants out of 33). The number of students with having a low level significantly decreased, from 61 % to 21 %. This indicates a qualitative improvement in the learning indicators of the participants in the group. Moreover, the most significant changes occurred for the change from “low” to “average” and “high”.

In the control group, the changes in the “high” level are not so significant: the indicator increased from 6 % to 9 %. After finishing the experiment, 39 % of students in the control group had an average level of qualities and skills that form the basis of group creative thinking (13 students out of 33), while initially this percentage was 36 % (12 participants out of 33). The indicator for the level “low” changed from 58 % to 52 %.

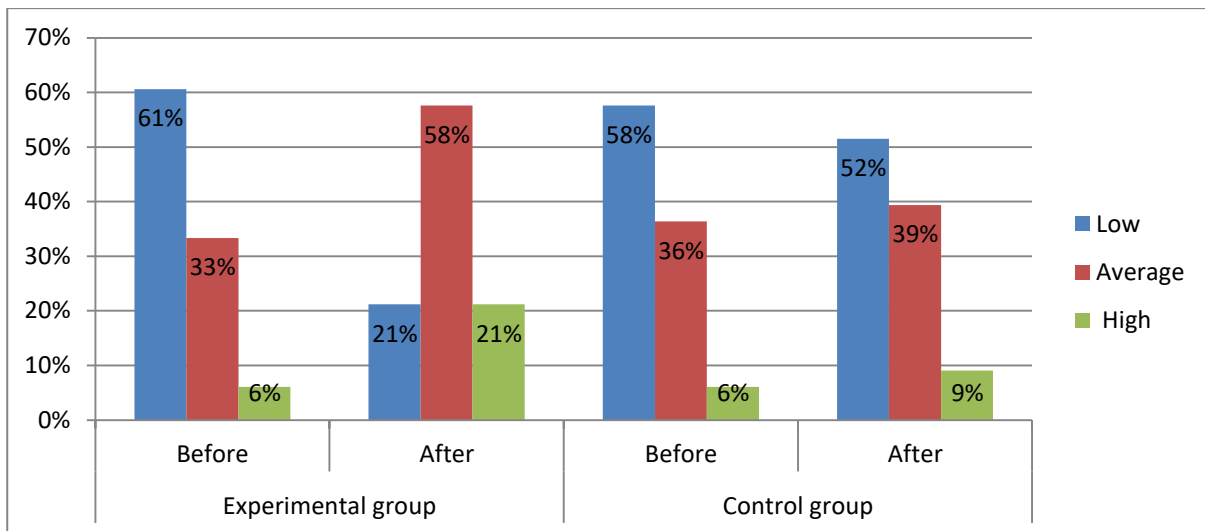


Fig. 1. Dynamics of changes in the level

So, there is also the dynamics in the levels in the control group, but it is less significant. In general, the pedagogical experiment allows us to conclude that the use of virtual team walls in teaching improves the quality of teaching in terms of formation of skills that form the basis of group creative thinking.

6. Conclusion

The study presents a solution to the problem caused by the need for additional research of possibilities of digital technologies and virtual services for development of creative thinking.

The skill “thinking creatively or being creative” is highlighted in many educational systems as one of the main learning outcomes. Every year there are more and more innovative technologies for development of creative thinking (mobile applications, educational robotics, programming, augmented and virtual reality, STEM technology, smart cards, etc.). In the context of the global transformation and spread of COVID-19, society's requirements are changing not only for the quality of training graduates of a digital school, but also for the form of education. Virtual communication, online collaboration, working with 3D objects, the use of software and hardware tools have become an indispensable element of social, pedagogical and methodological researches. In addition, creativity is a type of activity, a method of transforming reality. The group work methods in the study are used together with other teaching methods (experiment, comparison, classification, etc.).

For successful implementation of the proposed directions, it is recommended to use virtual team walls at the following stages of creative activity: obtaining theoretical information about the research object; organization of practice-oriented actions in an interactive online environment; creating conditions for creative insight in the group through presentation of a system of socially significant tasks; organization of group reflection and defense of team projects.

Earlier the idea that group creative thinking is manifested in words, thoughts and activities was noted. Therefore, the most significant are the following learning outcomes: to be aware of the meaning and motive of group activities; to form a need for self-expression through active participation in group discussion; to establish links between the goal of the team's activity and its result; to work according to a team plan; to express assumptions, stimulating the creative insight of the group; to analyze the progress of an individual task and the entire team project; to implement control and self-control; to express thoughts in direct interpersonal communication and virtual communication; to understand information culture.

Effectiveness of the proposed approach was tested during the pedagogical experiment. The research materials can be used to improve the quality of education through specially organized areas of support for group activities of students, focused on their creative development and preparation for future professional activities.

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