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Analysis of the Use of Visualization in Teaching Subjects of Different Ages

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Abstract

Global technological changes and the widespread use of information and communication technologies lead to the need to study the formation of information literacy skills of various demographic groups. The formation of the information economy creates increased requirements for the level of proficiency in digital and information technologies in order to successfully exist in a modern high-tech environment, which leads to the need for changes in the education system. These changes are aimed at developing the ability to understand the dynamics of the information world, to navigate the increasing flow of information. To this end, the latest technologies are actively used in educational programs, which, on the one hand, improve the quality of the educational process, helping to master educational content more effectively, and on the other hand, contribute to the mastery and use of digital and information technologies by students. This study examines the technologies of visual learning, which significantly improve the quality of the educational process. As part of the study of modern trends in the educational environment, the emphasis was placed on the use of visualization as a form of presentation of educational material. Different forms of visualization were investigated: active, passive, value-semantic, universal for different age groups of respondents (schoolchildren, students, adults), a total of 412 people participated in the study. For six months, they worked with different forms of visualization as part of the training. It was revealed that it is necessary to take into account age factors, motivational features that will allow you to build individual training routes based on operating with different forms of visual information, which will allow you to critically and systematically study materials, qualitatively develop skills and abilities, be effective, achieve goals and results.

Keywords: information literacy, digital skills, information technologies, training, education, visual technologies, virtual reality, visualization.

1. Introduction

The rapid development of information and communication technologies and the active use of these technologies in all spheres of human activity has led to the emergence of the concept of "information society". The further development of digital technologies and their active use in educational activities contributed to the introduction of such categories as information literacy and digital literacy into scientific circulation. Information literacy and digital skills form the information culture of an individual. Given the intellectualization and digitalization of almost all areas of business, the need to work in an information environment, simple knowledge and the

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ability to apply information and communication technologies in ordinary and professional activities is no longer enough (Bartolomé et al., 2021). The penetration of digital and information technologies into all spheres of life has led to the fact that the necessary competencies in the new reality are the so-called computational thinking, the ability to critically evaluate and create media content, the ability to allocate what is necessary in significant information flows, the ability to work in cloud environments, interact in virtual teams. The processes of acquiring and transferring knowledge have also changed, which are now carried out with the help of the latest information and digital technologies. The field of higher education has also become part of the digital transformation (Deja et al., 2021; Gálik, Oprala, 2021).

New media practices and new technologies are causing global changes in education, which leads to the expansion of traditional educational concepts. The need to introduce digital and information technologies into the educational space is due to the fact that, on the one hand, students need to acquire new skills and competencies that will allow them to be successful in a high – tech environment, on the other hand, educational technologies should quickly change to meet the emerging needs of the labor market, and universities should provide students with the opportunity to use the opening opportunities of digitalization, create accessible educational spaces. Digital and information technologies provide a variety of universal tools for designing educational processes. The combined use of real and virtual learning components allows you to use the advantages of some methods and avoid the disadvantages of others. Information technologies provide students with greater freedom and independence in mastering the educational material, develop their information literacy skills, since they need to master new technologies before using them in the learning process.

The main features of the education system in modern conditions are the development of personalized learning, the availability of easily accessible technologies, the expansion of the use of virtual technologies, continuous innovation (Fedorov et al., 2020; Gálik, 2020; Gáliková Tolnaiová, 2020; Levitskaya, Fedorov, 2021; Lyapunsova et al., 2021). The formation and development of information literacy at various stages of training helps students to understand the current trends in the development of science and technology, the nature of the information space, to use the latest achievements of technology and technology at the beginning in the learning process, and then in professional activities (Mail Pala et al., 2021). The use of audio technologies, visual technologies, and other opportunities provided by information and communication technologies allow the use of educational materials at a qualitatively new level, contribute to obtaining higher learning results due to the possibility of mastering more educational material (Gálik, Oprala, 2021; Nouri, 2019).

Information and digital technologies form an individual educational environment, an integral part of which is Internet platforms, thanks to which students can manage educational content. Given that the Internet provides unlimited access to information resources in the process of learning digital skills, it is important to learn how to assess the legitimacy of Internet sources, which involves the use of special methodological approaches in training based on information technologies. Digitalization of education makes it possible to expand traditional educational activities to include elements of real life in them with the help of, for example, game simulations or virtual objects. The technologies used stimulate students to improve the skills of searching and processing information, remote communications, increasing the level of information literacy.

2. Materials and methods

The analysis of the literature on the study of the use of various information and digital technologies in educational activities was carried out. The logic of the research was to analyze which information technologies are currently the most popular in the field of education and how visualization technologies are used in the learning process.

The purpose of the study is to analyze the possibilities and effectiveness of visual learning technologies and to propose methods of their use in the educational process.

The research program includes several main stages:

- at the first stage, visual forms of the material were selected, which were used in the training process for the next 6 months;

- at the second stage, these forms were used for 6 months in different age groups: older teenagers (15-16 years old); university students (25-30 years old); employees of organizations (45-50 years old);

- at the third stage, additional data were collected for analysis in different age groups: motivation for learning, the level of perception of the value of learning for the study participants;
- at the fourth stage, the data were systematized and analyzed according to the following criteria: how different visual forms are perceived by students of different ages, with different levels of motivation for learning, with different levels of perception of the value of learning;
- at the fifth stage, general conclusions were formulated based on the results of the work carried out.

The following materials were used for the study:

- the methodology of studying the attitude to academic subjects of G.N. Kazantseva (suitable for students of different ages);
- a questionnaire for evaluating the value of learning, designed specifically for research (defines 3 levels: low, medium and high level of learning value);
- a questionnaire for evaluating the effectiveness of teaching through the use of various forms of visualization (teachers and students themselves were interviewed).

The sample of the study was 412 respondents, 26 of them were teachers with at least 5 years of experience and 386 students of different ages:

- older teenagers (15-16 years old) – 116 people – 50 girls and 66 boys;
- students of higher educational institutions (25-30 years old) – 150 people-70 boys and 80 girls;
- employees of organizations (45-50 years old) – 120 people-80 women and 40 men.

The study was conducted for 8 months from November 2020 to May 2021.

Visual materials were divided into two main dichotomous groups:

- active visualization (transformation and transformation of visual data by students themselves) and passive visualization (just perception of visual data (graphs, drawings) without active interaction with them);
- visual images that are significant for students (for example, cases with participants of their age or characters in pictures of the respondents' age) – universal visual images (just pictures of nature, happy people).

The results of the study are correlated and confirmed by the results of the studies analyzed in the "Discussion" section below.

3. Discussion

The concepts of information literacy and digital skills that have emerged as a result of the digital transformation of all spheres of human life and the formation of the information society in the context of their formation and development are united by the use of digital information and communication technologies in the learning process. In one of the recent studies, a research team distinguish four stages in the development of educational technologies using information and communication technologies (Kačínová, 2019; Zawacki-Richter et al., 2018). The first stage is characterized by the growth of computer learning, which is associated with the mass use of computer technology in the learning process, the second stage is characterized by multimedia learning, the third stage is the emergence of computer networks that made it possible to use collaborative learning tools and the fourth stage is ubiquitous online learning in the digital age. In the modern conditions of digitalization of education, improving the digital skills and competencies of teachers is of particular importance. The transition to distance learning leads to the need for teachers to more actively study and use various information technologies in teaching.

The study by M. Beardsley, L. Albó, P. Aragón, D. Hernández-Leo identifies factors that can contribute to the introduction of digital technologies of distance learning by teachers based on the Fogg behavior model (Beardsley et al., 2021). According to the Fogg model, the effectiveness of target behavior depends on a combination of three factors: motivation, abilities and triggers. The need to use digital technologies in the learning process has significantly increased the motivation of teachers to master the latest information technologies and apply them in their teaching activities. A study by M. Beardsley, L. Albó, P. Aragón, D. Hernández-Leo shows that teachers' motivation to participate in activities related to digital technologies increased during the distance learning period. The research reveals that some teachers have been already sufficiently motivated to use digital technologies in teaching, while the motivation of others increased significantly. The forced transition to distance learning has led to the fact that almost all teachers have mastered digital educational technologies and, realizing the undeniable advantages of these technologies, will

actively use the acquired digital skills in their teaching practice in the future, regardless of changes in external conditions. In their study, O. Zawacki-Richter, U. Alturki, A. Aldraiweesh determined that the most popular questions in the study of information technology training were online learning, online courses and open educational resources (Zawacki-Richter et al., 2017).

Online learning promotes effective knowledge transfer and self-regulation of the educational process, helps students to improve information literacy (Humrickhouse, 2021). Quite a lot of research is devoted to distance learning technologies. In the scientific publications of the last ten years, the emphasis is on the development of computer learning environments and the integration of information and communication technologies of learning in various subject areas. The active discussion of the problem of distance education in the scientific literature began with questions on the use of distance technologies in higher education, and then other levels of education, for example, school education, were included in the range of issues. The main thing is to ensure a high level of interaction and cooperation between students and teachers, as well as between students (Money, Dean, 2019; Zawacki-Richter, Naidu, 2016).

Another popular topic of research that is of particular interest to researchers is mobile learning. In the work of H. Crompton, D. Burke, a review of studies related to mobile learning was conducted, it was determined that this topic is of considerable interest to modern scientists due to the fact that the number of mobile devices has increased significantly, mainly mobile device users are people aged 18 to 29 years, which is a typical age for students of various educational institutions (Crompton, Burke, 2018).

The studies have shown that the problem of using digital devices is relevant, and there are also two points of view on the usefulness of mobile devices in the learning process. Some authors believe that traditional teaching will be more effective, since the use of mobile devices in the classroom distracts students from performing educational tasks, and another group of authors points to the undeniable advantages of integrating mobile devices into the educational process, since they have a great potential to promote innovative teaching methods (Pedro et al., 2018). A promising direction in education is e-learning, which opens up new opportunities for both teachers and students (Rodrigues et al., 2019). Digital skills and competencies need to be developed not only at the school or university level.

The development of the skills to navigate in the information space, to search for the necessary information, to critically evaluate it, to understand how to use the information found in the context of their scientific ideas is a necessary skill for young scientists and graduate students when writing their scientific papers (Farooq, Maher, 2021). The multicomponent and meta-objective nature of the concept of information literacy allows students to strengthen the processes of self-education and forms a responsible attitude to the information reality. For more intensive training of information literacy, non-standard teaching tools, such as visual learning technologies, should be used.

A study by J.J. Loftus, M. Jacobsen, T.D. Wilson showed that during visual learning, spatial ability reduces cognitive load and potentially affects the student's performance when performing learning tasks using visual technologies (Loftus et al., 2017). The use of a cognitive-visual approach in teaching allows you to maximize the possibilities of visual thinking of students based on the cognitive function of visibility (Wu, Rau, 2018). Visualization technology has been used very successfully for learning a second foreign language (Sato, 2016).

The cognitive-visual approach allows us to design a visual learning environment, which involves the use of both traditional visual aids and special techniques and methods. The advantage of using visualization technologies in educational activities is the opportunity, on the one hand, to develop visual thinking of students, and on the other hand, to develop skills of working with modern information technologies, when students independently use computer and information technologies to create graphic images in a visual environment.

In the work of E. Gandolfi, K.W. Kosko, R.E. Ferdig shows that the use of video in teaching enhances the perception of educational material by students, increases their attention and generally improves the quality of the educational process (Gandolfi et al., 2021). The student can operate with a much larger amount of information compared to traditional methods of teaching. The analysis of the literature shows that one of the latest information technologies related to the creation of visual images, currently used are virtual reality technologies and augmented reality technologies. The goal of these rapidly developing technologies is to expand the physical space with additional objects, in the form of images created using digital devices and software. To support

visual training courses and modules, special visual learning tools are being developed, which are used to model scenarios of collaborative learning using visual technologies (Molina et al., 2018).

The advantages of using visualization technologies, one of which is virtual reality technology, are explored by G. Yang, Y.-T. Chen, X.-L. Zheng, G.-J. Hwang. Their study showed higher learning outcomes and higher motivation to learn from a group of students who used virtual reality technology compared to a group that used traditional teaching methods (Yang et al., 2021).

The use of virtual reality in the learning process helps to better study abstract concepts and increases the interest of students in studying both the physical and mathematical sciences and the humanities and motivates them to learn (Liono et al., 2021). Educational institutions successfully use augmented reality technologies, which have proven their effectiveness in the context of motivating students and successfully mastering training courses (Dalim et al., 2017; Garzón et al., 2019).

The active introduction of augmented reality technologies in the field of education is determined by the capabilities of this technology, as well as the ease of its use through mobile devices, such as smartphones or tablets. Augmented reality combines physical and digital reality to create an image, three-dimensional objects, allowing you to better perceive and understand the surrounding reality. Unlike virtual reality, which is an artificially created environment, augmented reality expands the existing environment by supplementing it with virtual elements, for example, three-dimensional models of buildings, cars, animals or people. The potential of augmented reality allows it to be used not only in the higher education system, but also in schools, although it is in universities that this technology has shown the greatest effectiveness (Cabero-Almenara et al., 2019).

An analysis of the literature on the use of the visual component in the learning process showed that researchers mainly analyze the use of virtual and augmented reality technologies in the context of their technical capabilities, while methodological issues of visualization of the educational process are practically not studied.

4. Results

The results of the study are presented in detail below.

As part of the first stage, visual forms of the material were selected, which were used in the learning process for the next 6 months at various humanitarian courses, where a large amount of textual information and abstract concepts (history, sociology, fundamentals of management, philosophy) were selected. Among the recommended forms, teachers were asked to use pictures, clips (passive visualization), infographics, scribing, sketching (active visualization), as well as tasks and methodological materials with typical universal pictures or maximally adapted to the needs of the audience (adults who studied management, for example, considered cases, visual sketches based on their own or the most similar professional experience). In total, 100 visual forms and images were selected for each age group within the framework of the disciplines, subjects and courses being taught, and approximately 20 tasks were developed in order to use active forms of working with images.

During the second stage, these forms were used for 6 months in different age groups: older teenagers (15-16 years old); university students (25-30 years old); employees of organizations (45-50 years old). Individual data were not collected here on purpose, but teachers freely observed the activity of students, their interest in the material and the manifestation of creative initiative. The observation data were analyzed, systematized, processed using frequency analysis and presented in the table (Table 1).

Table 1. Data on the results of observation of students during the use of visualization in teaching

Monitoring parameter	Older teenagers (15-16 years old)		University students (25-30 years old)		Employees of organizations (45-50 years old)	
	Before using visualization	After using visualization	Before using visualization	After using visualization	Before using visualization	After using visualization
student activity	24 %	46 %	43 %	68 %	15 %	35 %
interest in the material	30 %	50 %	27 %	55 %	19 %	59 %

manifestation of creative initiative	12 %	33 %	29 %	50 %	7 %	30 %
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The data in [Table 1](#) confirm that the use of visualization maximizes interest in learning, activity and creativity when performing various tasks.

As part of the third stage, additional data were collected for analysis in different age groups: motivation to learn, the level of perception of the value of learning ([Tables 2, 3](#)).

Table 2. Data on the results of assessing the motivation of students during the use of visualization in teaching

Motivation level	Older teenagers (15-16 years old)		University students (25-30 years old)		Employees of organizations (45-50 years old)	
	Before using visualization	After using visualization	Before using visualization	Before using visualization	After using visualization	Before using visualization
High	15 %	29 %	30 %	55 %	5 %	35 %
Medium	45 %	60 %	30 %	40 %	35 %	45 %
Low	40 %	11 %	40 %	5 %	60 %	20 %

These results confirm the change in the level of motivation, which allows us to use visual forms of work in groups with a particularly high resistance to mastering new material, especially of those older 45 years.

Table 3. Data on the results of students' perception of the value of learning

Learning value level	Older teenagers (15-16 years old)		University students (25-30 years old)		Employees of organizations (45-50 years old)	
	Before using visualization	After using visualization	Before using visualization	Before using visualization	After using visualization	Before using visualization
High	5 %	40 %	10 %	25 %	7 %	40 %
Medium	30 %	50 %	30 %	60 %	23 %	55 %
Low	65 %	10 %	60 %	15 %	70 %	5 %

The data in [Tab. 3](#) confirm the change in the level of assessment of the value of learning by students personally for themselves, which allows us to recommend starting to use visual forms of work in training as early as possible from an earlier age. This will allow us to implement the concept of "lifelong learning" at a more effective and conscious level.

As part of the fourth stage, the data were systematized and analyzed according to the following criteria: how different visual forms are perceived by students of different ages, with different levels of motivation for learning, with different levels of perception of the value of learning.

- active visualization (that is, working with the transformation of images is more memorable, but it should be dosed, since it takes a lot of intellectual effort and requires systematic and imaginative thinking at a sufficiently high level). It is easier for teenagers and students to use active visualization as their own intellectual product, less often people of the adult age group (it is more difficult for them to be active, creative; it is easier to do something according to a pre-created template). All these conclusions can be explained by the age characteristics of the study participants, as well as the peculiarities of the mentality and upbringing of the older group of people, their cultural patterns of behavior;

- passive visualization (perception of visual images without active processing) was perceived by all respondents with less interest, but at the same time it significantly increased the

memorability of the material, but not its semantic assimilation. Passive visualization is used 6-7 times more often in the activities of teachers than active visualization, since it requires less effort and time spent on preparing the material. Also, passive visualization requires less creativity and creative study of methodological materials from the teacher. It is easier for teenagers and people of the adult age group to perceive passive visualization (it is easier for them to do something according to a pre-created template, without using additional efforts);

- visual images that were important for students (for example, cases with participants of their age or characters in pictures of the respondents' age) are used by teachers quite rarely, but if they were used in an active form, then they were remembered by students as much as possible, increased their interest in the material, contributed to the manifestation of creativity in performing tasks. All this can be explained by the value value of this visual material for students. It is easier to work with such images as teenagers and students, as well as people of the adult age group. All students tried to be active in learning, non-standard solutions, to move away from pre-created templates;

- universal visual images (just pictures of nature, happy people, people doing their own thing) were well absorbed, did not cause a strong emotional response, rather, they were perceived as an additional distracting background (according to the results of observation in all groups of respondents, it was found that diagrams, graphs, text were remembered better when there were no additional background images that distracted them). Universal images were well perceived at the beginning and at the end of presentations, lectures – they created a certain educational mood, but were quickly forgotten. This can also be explained by the huge amount of streaming information that people perceive every day, to which the psyche has learned to adapt. This could be observed in all age groups;

At the fifth stage, general conclusions are formulated based on the results of the work carried out, they are presented below.

5. Conclusion

The conducted research allowed us to draw a number of conclusions:

- respondents of each age group recognize learning using visual technologies as more effective and interesting;

- respondents with initially high motivation to study, but its low value for themselves (who are forced to study due to external circumstances) reacted more often and were involved in the active process of working with visual material, which, in general, increased the value of studying for them personally, and a sincere interest in it grew;

- respondents with initially low motivation to study, but its high value for themselves ("I don't really want to make an effort, but it's important for me") more often worked comfortably in the format of passive visualization-where it was not necessary to make efforts, develop a creative approach, create their own;

- respondents with initially low motivation to study and its low value for themselves ("I don't really want to make an effort, I don't care") more often worked comfortably in the format of passive visualization and reacted to universal images – where no effort was required, they refused to use active visualization, it was difficult to get involved in the educational process based on it;

- respondents with initially high motivation to study and its high value for themselves ("I really want to make efforts, this is important for me") more often worked comfortably in the format of active visualization, found new meanings and interest, developed their product, made new projects and more often not just reproduced the learned material, but also tried to apply it as much as possible in new situations.

All the data obtained indicate that it is possible to use a multi-level system for organizing visual information, data, and materials used in teaching different age groups. It is especially necessary to focus attention on the use of active forms of working with images in adolescent groups and in groups of older students in order to increase motivation, awareness in learning and interest in the material that is caused by internal motivation, and not by external circumstances. Also, visual materials allow you to adapt faster to the learning process, new topics, complex materials and it is easier to explain what is not clear when interacting with teachers.

Visualization is a universal language of work, training and any activity, which has repeatedly proved its effectiveness.

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