SMART-Lecture Methodology as Modernization of Blended Training at HigherEducation Establishment in Conditions of Forced Unpredictability

Stanislav Zabara[1], Lesia Kozubtsova[2], Oleksii Beskrovnyi[2], Igor Kozubtsov[3(✉)], and Olena Mamonova[4]

[1] Open International University of Human Development "Ukraine", Kyiv 03115, Ukraine
[2] Kruty Heroes Military Institute of Telecommunications and Information Technology, Kyiv 01011, Ukraine
lesia.kozubtsova@viti.edu.ua, olbezkrovnyy@i.ua
[3] Lutsk National Technical University, Lutsk 43018, Ukraine
kozubtsov@gmail.com
[4] Donetsk State University os Internal Affairs, Kropynytskyi 25006, Ukraine
mamonovaddli@ukr.net

Abstract. The subject of the research is the theoretical and practical basis for the use of blended learning in higher education institutions with specific (phenomenal) learning conditions. The object of research is the modernization of lectures to the Smart-lecture format. The relevance of the research topic is confirmed by the urgent need to improve the educational process in higher education institutions with specific conditions for students in wartime to maximize the effective use of short periods of time between air raids. The result of the psychological and pedagogical research is aimed at increasing the level of assimilation of lecture information through the lecturer's successful influence on the areas of visual thinking development. The purpose of the article is to substantiate the content of the concept of Smart-lecture, the methodology of its implementation in a blended learning environment to ensure the safety of all participants in the educational process. The SMART-lecture in the updated format is presented to higher education students as an interactive form of visual education. The solution to the scientific problem is aimed at increasing the level of assimilation of educational information by students through its visualization and creating a safety zone in educational institutions for all participants in the educational process in conditions of war (or force majeure). The author emphasizes the need to use visual means of interactive computer technologies as an integral part of modern education in higher education institutions. It is concluded that the use of such interactive forms of organization of visual study of educational components as SMART-lecture promotes the development of visual learning, activates students in the learning process, which increases the effectiveness of learning. Currently, a scientific and pedagogical experiment is underway to test the effectiveness of the proposed solutions both in an educational institution with specific learning conditions and in ordinary ones. The preliminary scientific result obtained in this work already expands the scientific boundaries of pedagogical science in the field of theory and methods of teaching educational

Z. Hu et al. (Eds.): ICCSEEA 2024, LNDECT 242, pp. 656–669, 2025.
https://doi.org/10.1007/978-3-031-84228-3_57

disciplines of educational components to higher education students in the context of a tendency to reduce motivation, and also clearly contributes to the creation of a safety zone for all participants in the educational process in wartime in educational institutions with specific learning conditions.

Keywords: Smart-lecture · improvement · form · training · teaching · institution of higher education · a student of higher education · lecturer · teacher

1 Introduction

1.1 Problem Statement

The rapid development of computer technologies certainly affects the educational process. Traditional teaching of lectures is obviously not interesting for those seeking higher education, it is necessary to search for new approaches to learning. In lecturing practice, visual methods of training are becoming more and more common, which makes it easier for the teacher to present educational information to students.

It is known that students of higher education in the humanitarian and technical areas perceive the concept of educational material in higher mathematics by means of the traditional model of education in different ways. As a result of different types of perception, students of higher education lose interest in perceiving the educational discipline of the educational component, the effectiveness of the learning result decreases. Based on these circumstances, there is a need to search for approaches to improve the teaching of lectures by visualizing mathematical information, which plays an important role in the perception of information by students of higher education [1]. Since modern students of higher education are increasingly willing to master the digital educational environment [2], it is possible that in the near future lecturers should be ready to conduct lectures using interactive computer technologies, be able to create their own educational and digital environment: either classroom lessons using interactive whiteboards, or distance lessons – using the Internet and platforms for distance lessons.

1.2 Literature Review. Analysis of Recent Research and Publications

Solving the problem of increasing learning efficiency through the visualization of learning information has been the subject of research by many scientists. One of the first publications [3] presented experimental results that confirm the effectiveness of visualizing educational information.

Since the term “visualization” has many meanings, teachers most often mean the process of transforming information into a visually perceptible form: a diagram, graph, figure, scheme, table, etc. However, such an understanding of visualization implies minimal mental and cognitive activity of education seekers, and visual didactic tools perform only an illustrative function [4, p. 113]. Therefore, under the visualization of educational information, we mean the arrangement and structuring of a fairly large volume of information in a visual form that is easily perceived and forms a visual image in the student’s memory.

Analysis of further scientific research shows the effectiveness of using interactive SMART boards in the educational process not only for visualization, but to a greater extent as a means of increasing cognitive activity and learning efficiency in computer science classes [5]. Similar confirming results were obtained in the study [6]. Teachers note that the use of interactive SMART boards in lecture practice has significant advantages in terms of motivation, attention and behavior of students of higher education, rather than using other tools. Along with this, there are researchers' opinions [7] on the lack of results that will clearly demonstrate that interactive whiteboards improve academic performance. Interactive whiteboards by themselves, do not improve anything. Only the methodically correct use of visualization tools allows you to influence effectively the educational process of students of higher education.

In their work [8], the authors note that using traditional data visualization methods, it is difficult to visualize abstract facts to obtain valuable information about complex multidimensional data sets. One of the main problems is the high cognitive load during the interpretation of information. Three-dimensional visualization of information in the context of our study is important for justifying the need for such a display of educational information to improve its perception by students of higher education.

1.3 Highlighting Aspects that Are Understudied

Currently, there is a sufficient number of educational and methodological manuals for higher education using visualization tools aimed at developing visual thinking in order to increase the effectiveness of teaching various academic disciplines to students of higher education. These and many other studies confirm that "the informatization of education and the development of electronic subject teaching method fundamentally change the classical theory and methodology of teaching and the methodology of researching scientific problems of subject teaching" [2]. Thus, our study is a logical generalization of scientific research on improving the methods of training cadets.

1.4 Purpose of the Article

The purpose of the article is to consider an approach to solving the scientific and applied problem of increasing the interest of higher education students in studying academic disciplines in conditions of forced unpredictability due to the use of the SMART-lecture methodology.

1.5 Research Objectives (Goals)

To achieve this purpose, the following objectives are set: to analyze the latest research and publications on the topic of the identified problem;;to state your own research results in solving the specified problem.

2 Research Methods

2.1 Research Tools

To solve the tasks defined by the authors, the following methods of theoretical research were used: analysis and generalization of scientific literature by research direction; the method of going from the abstract to the concrete; method of analytical and comparative analysis when evaluating the novelty of research results; generalization when formulating conclusions and recommendations regarding the continuation of further research.

2.2 Reliability and Accuracy of Results

Reliability of the results of the study is ensured by the correctness of using mathematical apparatus and research methods.

2.3 Methodological Basis of the Study

The object of scientific and theoretical research is not just a separate phenomenon, a specific situation, but a whole class of similar phenomena and situations, their totality. The methodological basis of the research is the ideas of L. Vygotsky, P. Halperin, S. Rubinstein (pedagogical psychology of human perception of information).

2.4 Limitations in the Application of the Results

It is important to eliminate any potential biases by focusing on the Ukrainian context, which will provide a more balanced view of the problem. Therefore, the use of the fi ndings in other countries may be considered as one of the possible options at the preliminary analysis stage.

3 Research Results

3.1 Concept of SMART Lecture as a Modern Form of Visual Education

Along with well-known visualization tools, there are also SMART-lectures as a modern interactive form of visual training in higher education institutions. The essence of such a type of initial class as a "SMART-lecture" is based on research in the field of cognitive-visual methods [7] and the selection of some necessary components of visual learning: use of visualization tools; inclusion of specially developed visualized tasks; addition of historical facts, associations in visualized forms; introduction of interactive computer technologies; construction of a visual learning environment.

According to the author [7], all the necessary components of visual learning are successfully combined in such a form of training organization as a SMART-lecture.

The concept of SMART has been used in the field of education since the release of the first interactive SMART Board, when the concept of "SMART-lesson" appeared. SMART translated from English means "clever" and is used in management [9], it is presented in the Table 1.

Table 1. Similarity of constituent concepts in management and lectures

Constituents	Content of components (similarity)	
	Management	SMART lecture
Specific	contains a clearly formed idea	contains a clearly formed proof or algorithm for solving the problem in the form of a closed block diagram, which is opened during the course of the lecture;
Measurable	methods of measurement	the lecturer predicts methods of measurement, memorization of the content of the lecture by students;
Agreed	coordinated with the employee's personal tasks, the company's mission and the client's needs	interactive presentation of information, presented using such information management methods as hyperlinks and the "Drag and Drop" utility;
Realistic	adequate to the current situation, not overstated/understated, opportunities correspond to resources	the lecture is created within the capabilities of the interactive whiteboard software;
Timed	a clear deadline for achieving the goal is set	available to applicants at any time, a video recording of the lecture by means of the interactive whiteboard itself

According to the author [10], the SMART-lecture is an interactive form of organizing visual learning with the following components:

interactive whiteboard is the main technical means of education;

the table is the main means of visualizing the proof of the theorem;

block diagram is a visual representation of the strategy for solving educational problems;

"Drag and Drop" is the main method of operation when solving visualized tasks and deriving formulas;

hyperlinks are the main element of navigation according to the content of the study;

saving video recordings from the board for possible visual repetition of the information presented at any time;

automated control and self-control of knowledge of lecture material – factual or terminological;

formulation of the problem.

Thus, the abbreviation SMART-lecture is formed.

Based on the analysis of Fig. 1, a SMART-lecture can be called a "clever lecture" that promotes effective learning.

The term "SMART-lecture" can be considered in two aspects:

1) as an interactive form of organizing visual learning;

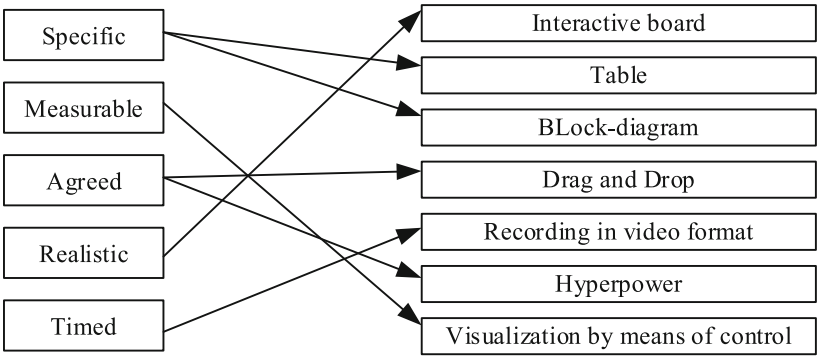

Fig. 1. Relationship between SMART criteria and SMART lecture components

2) as an electronic educational resource (Fig. 2).

A SMART-lecture as an interactive form of organizing visual learning using an interactive whiteboard, and a SMART-lecture as an electronic educational resource is created using interactive whiteboard software using graphic editors, Microsoft Office programs, and browsers. By interactive whiteboard we mean a technical device of interactive computer technologies, represented by a large interactive screen in the form of a white magnetic marker board. To present a SMART-lecture, as an interactive form of organizing visual learning, you need to know the device of the interactive whiteboard and its modes of operation, and to create a SMART-lecture you need to know the software of the interactive whiteboard, be able to use or develop electronic didactic materials in the appropriate software. Since different interactive whiteboards with different sensor technologies have a similar interface, it is enough to master the interface of one software package to create digital didactic materials.

The SMART-lecture technology can be presented in the form of a diagram (Fig. 2).

Selection of Educational Information. The topic of the lecture is set, the lesson objectives are set, and the lesson plan is drawn up. The content of the SMART-lecture must include evidence, historical facts, examples of solved tasks, and questions for summarizing the lecture.

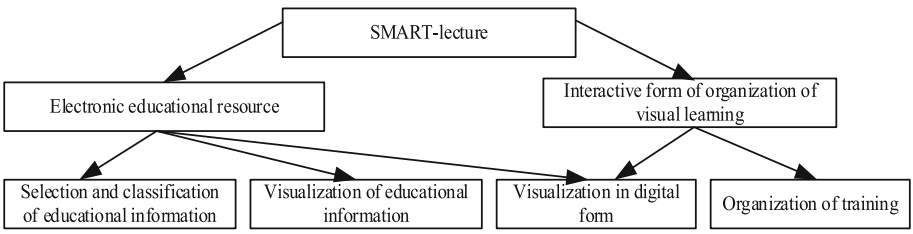

Fig. 2. Model of SMART-lecture construction technology

Visualization of Educational Information. We consider this component of building a SMART-lecture difficult because of the visualization process itself: organizing textual information in such a way that it is visual, easy to read and remember. It is necessary to visualize the prepared tasks on this topic, describe the visual strategy for solving mathematical tasks using block diagrams, think over the visual proof of a theorem or formula.

Visualization of Information in Digital Form. To build a SMART-lecture as an electronic educational resource (EER), you should use SMART Board interactive whiteboard software (SMART Notebook), as well as graphic editors, Microsoft Office programs, and browsers. SMART Notebook software satisfies the principle of an open system for creating EOR, as it is enough to have elementary skills in Microsoft Office programs to use it.

3.2 Methodology of Reading a SMART Lecture

A SMART-lecture is conducted by a leading lecturer in a classroom with connected projection equipment and an interactive whiteboard. Before the start of the lecture, the lecturer or the support staff of the department performs the screen calibration, which is necessary to precisely adjust the touch to the interactive whiteboard. Then it turns on the recording of all actions on the board to create video files. The recorded video file is posted on the portal of the distance learning system.

Before the lecture, students receive the following reference materials: block diagram with empty blocks; a table for proving the theorem with some missing steps; templates for answering questions when summarizing the lecture.

Auxiliary handouts are issued to applicants in advance. Of course, the lecturer makes sure that the applicants note down not only the basic definitions, formulas, and formulation of theorems. The applicants then use the completed handouts in practical, seminar classes.

The results of the lecture by the lecturer are carried out by the lecturer as follows: applicants receive template sheets; an interactive crossword puzzle is included on the board; applicants record their answers in template letters; the lecturer includes the correct answers; applicants test their knowledge.

3.3 Discussion of Research Results and Experience in Conducting SMART-Lectures in Conditions of Uncertainty

In the conditions of war, not only the quality of the lecture plays a key role, but also the lecturer has an effort to focus on creating safe conditions for staying in educational institutions. It should be noted that as a result of the unpredictability of air alarms, there is also a forced reduction of classroom time for lectures. Undoubtedly, this creates conditions for violation of the traditional logic of the educational process. And although the methodological department of the Ministry of Education and Science of Ukraine has developed four models of education organization: in-person, distance, mixed and individual forms (externship or family form) [11, p. 43], they do not completely solve the specified problem.

Scientists from the number of teachers who work in the specified conditions of martial law in institutions of higher education noted the undoubted dominant advantage in the application of a mixed form of education in the organization of the educational process [12]. Studies on the implementation of blended learning, which combines traditional technologies with distance learning, show good results.

In order to ensure balance under such conditions, it is rational to apply in institutions of higher education mixed training of students using the pedagogical technology of the "anticipatory learning method" [13], which has been modernized as the technology of the "inverted" class, the essence of which is the permutation of key components of the educational process [14]. The "inverted" educational process is implemented in the form of successive stages: before the classroom - classroom - after the classroom work, while before the classroom and after the classroom work is implemented in a digital educational and scientific environment. Classroom work is independent work in a digital educational and scientific environment, which continues in the classroom. The transition to a digital educational and scientific environment occurs again at the stage after the classroom work to consolidate the material (Fig. 3).

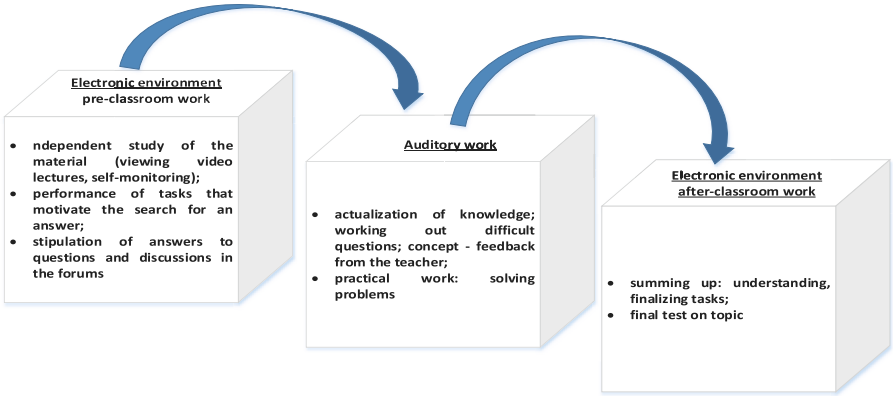

Fig. 3. Inverted educational process in reading a SMART-lecture

The application of the blended learning model in the SMART-lecture of the educational components provides sufficient flexibility and versatility, which are so important in the conditions of war. A mixed form of education is a model built on the basis of integration and mutual complementation of traditional and electronic learning technologies, which involves reducing classroom classes due to the transfer of certain types of educational activities to a digital educational and scientific environment.

Transferring part of the training course to the format of independent distance learning allows you to minimize the hours of work of the lecturer, as well as to create an environment for the implementation of the individual learning trajectory of each student by providing the opportunity to complete part of the course online in a mode convenient for him. For each shortened lesson, the educational activity is redistributed between pre-classroom, classroom and post-classroom work. In the new scheme, the central place is

occupied by classroom lessons, around which classroom work is built before and after them (Fig. 3).

The expected effect of the introduction of a SMART-lecture in a mixed format will be calculated based on the results of E. Dale's research on the relationship between the quality of the material learned during training and the forms of its teaching (see Table 2) [15].

Table 2. Cone of experience according to experimental data of E. Dale

Activity	Memorization of information	Acquisition of ability
Reading	up to 10%	Define, list, describe, clarify
Listening to a lecture	up to 20%	
Watching drawings	up to 30%	Perform, Execute, apply
Video watching	up to 50%	
Participation in the discussion	up to 70%	Analyze, create,evaluate, develop
Imitation of real activity	up to 90%	

Based on the data from the Dale cone, it is possible to assume and conclude that due to the use of a mixed form of education and SMART-lecture, it is possible to ensure:

in out-of-class time up to 20% mastery of the lecture material;

during the classroom time of the SMART-lecture thanks to the clarity (drawings, tables, etc.) and its organization for the students in the form of participation in the discussion up to 70%.

A large reserve of the time budget allocated for independent work will allow applicants to study deeply the educational material, prepare for the SMART-lecture and, as a final result, acquire quasi-professional experience [13; 14; 16]. Previously acquired knowledge outside the classroom plays a significant role in the assimilation of new knowledge and skills. Previously acquired knowledge consists of short-term memory and long-term memory. Although it this is a generally accepted learning phenomenon, It is difficult to analyze empirically the influence of prior knowledge on learning [17]. It is confirmed by the results of the conducted research. Academic success of students depends on the time spent on extracurricular activities [18]. And once again about increasing the level of assimilation of knowledge.

3.4 Research Methodology

To find out whether there really is a difference between a traditional lecture (TL) and a SMART-L, a quick survey of respondents from among students and cadets was conducted in the form of a questionnaire. The survey was conducted in a relaxed atmosphere. Respondents could choose several answers in the survey. A total of 110 respondents were interviewed (see Table 3).

Table 3. Quantitative distribution of respondents

Respondents	Educational institution	Specialty	Number of respondents
Cadets	Kruty Heroes Military Institute of Telecommunications and Information Technology (MITIT)	172 Telecommunications and radio engineering, 122 Computer science, 125 Cybersecurity	21
Students	Lutsk National Technical University, (LNTU)	121 Software engineering, 122 Computer science	49
Students	Open International University of human development "Ukraine" (OIUHD)	121 Software engineering, 123 Computer engineering, 125 Cybersecurity	40
Total respondents:			110

Criteria, indicators and parameters used for evaluation. The list of questions (questionnaires) offered to respondents is presented in Table 4. Respondents had the opportunity to choose several answers. Respondents put a " +" sign against the corresponding field. The count was made by simple summation.

Table 4. List of questions (questionnaire)

No	Questions to the respondents	Answer			
		T-L		SMART-L	
		yes	no	yes	no
1	Does the lecture contain a well-formed proof or algorithm for solving a problem in the form of a closed flowchart that opens during the lecture?				
2	Is the information presented interactively?				
3	Is a video recording of the lecture available to students at any time using the interactive whiteboard itself?				

The distribution of respondents' answers is presented in Table 5.

Thus, the results of the survey of students' opinions show 3 out of 5 criteria (Table 1) of the distinctive features of SMART-L compared to T-L.

Table 5. Results of the survey. Distribution of respondents' answers

Questions	Distribution of respondents' answers											
	MITIT				LNTU				OIUHD			
	T-L		SMART-L		T-L		SMART-L		T-L		SMART-L	
	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
1	4	17	17	4	7	42	42	7	6	34	36	4
2	8	13	19	2	3	46	40	9	2	38	31	9
3	0	21	21	0	0	49	36	13	0	40	29	11

We certainly agree with the opinion of the authors that to improve teaching and learning, it is necessary to use assistive technologies [19]. For example, the use of gamification, but in such a way that the method of learning through the game does not turn into a pure game [20–23].

4 Summary and Conclusion

Using interactive forms of organizing visual training of students in higher education institutions, such as the SMART-lecture, is one of the innovative and effective directions in modern education. Unfortunately, despite the fact that the implementation of SMART-lectures in the educational process in higher education institutions is relevant and in demand, not all lecturers (due to the age limit) are ready to create such lectures due to the large amount of time required for their preparation. However, it should be noted that such expenditure of time is justified, since the SMART-lecture as an electronic educational resource can be used an unlimited number of times, periodically updating it with new tasks. The application of SMART-lectures in combination with the technology of anticipatory learning (flipped class) occurs during independent work, and during classroom work is allocated to tasks, exercises, conducting laboratory and practical research, individual consultations with the teacher. Blended learning allows you to focus on the shortest ways to achieve the planned results, as the usual boundary between independent and classroom work of students is erased. Therefore, the use of a mixed form of training and anticipatory training will allow not only to ensure the implementation of the curriculum for mastering the educational component, but also to maximally ensure the opportunities of the applicants to preserve life and health in conditions of war or other forced contingencies.

4.1 Expanding the Boundaries of the Scientific Field

The scientific result obtained in the work expands the scientific boundaries of pedagogical science in the field of theory and methods of teaching educational disciplines of educational components to students of higher education in conditions of a tendency to decrease motivation. Thus, the expansion takes place in the systemic unity of the philosophy of education and the theory and methodology of professional education.

4.2 Scientific Novelty. Scientific Justification

For the first time, a SMART-lecture was offered in combination with a blended form of education to intensify the training of higher education students and create a safe territory in educational institutions for all participants in the educational process in war (or force majeure) conditions.

4.3 Practical Use

As a result of the damage and destruction of the infrastructure, the premises of higher education institutions, and the loss of educational and research equipment, a flexible universal mechanism is needed to ensure the continuity of the educational process in conditions of war and long-term air strikes. The use of SMART-lectures in combination with a blended form of education allows in practice to overcome new challenges in creating safe conditions for the staying educational institutions of all participants in the educational process, and the most important goal of pedagogical activity in war conditions is the transformation of each educational institution into a security territory. Based on the obtained data, at the end of the experiment, it was found that:

the use of SMART-lectures in the teaching of higher mathematics to students of higher education contributes to a greater extent to meaningful study, rather than formal memorization;

such lectures are interesting for applicants, they are lively;

schematic and tabular presentation of mathematical information contributes to better understanding and memorization, applicants are ready to use such forms of presentation of educational information in other disciplines.

4.4 Prospects for Further Research and Study

The research is expected to bring more academic and practical value. For it, it is necessary to implement systematically the methodology of hybrid use of SMART-lectures in institutions of higher education.

Acknowledgment. The authors would like to express their gratitude to the organizers of The 7th International Conference on Computer Science, Engineering and Education Applications (ICCSEEA2024), as well as to the general sponsors of the National Technical University of Ukraine “Igor Sikorsky Kyiv Polytechnic Institute”, National Aviation University, Lviv Polytechnic National University, Kharkiv National University of Radio Electronics, Kharkiv, Wuhan University of Technology, Polish Operational and Systems Society, International Research Association of Modern Education and Computer Science, for free publication of scientific articles.

References

1. Nezhyva, O.: The aspects of smart education in the world. Khazar J. Humanit. Soc. Sci. **24**(3), 62–72 (2021)
2. Pardała, A.: Informatization of mathematics education: didactic opportunities, experience and foreign trends. Inform. Educ. **6**, 49–55 (2019). (in Russian)

3. Shatalov, V.: Fulcrum. Moscow, Pedagogika, **159** (1987). (in Russian)
4. Trukhan, I., Trukhan, D.: Visualization of training information in the learning of mathematics, its importance and the role. Adv. Curr. Natl. Sci. **10**, 113–115 (2013). (in Russian)
5. Ganashok, A.: Interactive whiteboard as a means of increasing the cognitive activity and efficiency of learning in the classroom of informatics. Inf. Technol. Learn. Tools **51**(1), 21–35 (2016)
6. Smith H.J., Higgins S., Wall K., Miller J.: Interactive whiteboards: boon or bandwagon?. a critical review of the literature. J. Comput. Assist. Learn. **21**(2), 91–101 (2005). https://doi.org/10.1111/j.1365-2729.2005.00117.x
7. Dalinger, V.: Theoretical foundations of the cognitive-visual approach to teaching mathematics. Omsk, OSPU **146** (2006). (in Russian)
8. Wijayawardena, A.S.K., Abeysekera, R., Maduranga, M.W.P.: A systematic review of 3D metaphoric information visualization. Int. J. Mod. Educ. Comput. Sci. (IJMECS), **15**(1), 73–93 (2023)
9. Doran, G.T.: There's a S.M.A.R.T. way to write management's goals and objectives. Manage. Rev. **70**(11)(AMA FORUM), 35–36 (1981)
10. Lebedev, V.: Effective training of combinatorics and probability theory. School Technol. **2**, 126–134 (2012). (in Russian)
11. Education of Ukraine under martial law. Information and analytical collection. Kyiv: Institute of educational analytics, 358 (2022). (in Ukrainian)
12. Ducational process under martial law in Ukraine. Materials of the All-Ukrainian scientific and pedagogical advanced training, (Odessa, May 3 – June 13) [C]. Odessa: Helvetika publishing house, 504 (2022). (in Ukrainian)
13. Lysenkova, S.: The method of anticipatory learning: a book for teachers: from work experience. Moscow: Enlightenment, 192 (1988). (in Russian)
14. Bergmann, J., Sams, A.: Flip Your Classroom: Reach Every Student in Every Class Every Day. International Society for Technology in Education, Washington, DC (2012)
15. Dale, E.: Audio-Visual Methods in Teaching. 3rd ed. New York: Holt, Rinehart & Winston (1969)
16. Nechkina, M.: Increasing the effectiveness of a lesson. Communist **2**, 51 (1984)
17. Navandar, S.K., Kiwelekar, A.W., Laddha, M.D.: A performance analysis of the impact of prior-knowledge on computational thinking. Int. J. Mod. Educ. Comput. Sci. (IJMECS) **15**(2), 54–61 (2023). https://doi.org/10.5815/ijmecs.2023.02.05
18. Sharma, N., Appukutti, S., Garg, U., Mukherjee, J., Mishra, S.: Analysis of student's academic performance based on their time spent on extra-curricular activities using machine learning techniques. Int. J. Mod. Educ. Comput. Sci. (IJMECS). **15**(1), 46–57 (2023)
19. Adebayo, E.O., Ayorinde, I.T.: Efficacy of assistive technology for improved teaching and learning in computer science. Int. J. Educ. Manage. Eng. (IJEME). **12**(5), 9–17 (2022)
20. Kapp, K.: The gamification of Learning and Instruction Game-Based Methods and Strategies for Training and Education. Pfeiffer, San Francisco, USA (2012)
21. Tkachenko, O.: Gamification of education: formal and informal space. Topical Issues Humanit. **11**, 303–309 (2015). (in Ukrainian)

22. Petrenko, S.: Gamification as an innovative educational technology. Innov. Educ. **2**(7), 177–185 (2018). (in Ukrainian)
23. Lishchina, V., Kozubtsov, I., Kozubtsova, L.: Choice of pedagogical training technologies as a key problem teacher – subject of the educational process. In: International Scientific and Methodological Conference "Innovative Technologies in Military Education", (Odessa, June 25). Odessa: Military Academy, pp. 225–226 (2021). (in Ukrainian)