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EVALUATING THE EDUCATIONAL POTENTIAL OF AN E-LEARNING COURSE IN BLENDED LEARNING CONTEXTS

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Abstract

Background. The article is devoted to the study of the problem of identifying and testing key criteria for objective assessment of the quality of an e-learning course in a blended learning environment.

The aim of the study is to substantiate and verify the effectiveness of indicators and criteria for assessing the visualisation and visibility of an e-learning course as significant characteristics of its educational potential in the conditions of general and vocational education.

Materials and methods. The research methodology is based on the ideas of innovativeness and subjectivity as the main strategic guidelines in the organisation of general and vocational education. The work was carried out in two stages. Identification of the level of effectiveness of the e-learning course "Genetics for All: Just about Complex" based on the evaluation of schoolchildren's and students' performance after its completion. And also - element-by-element assessment of the educational potential of this e-learning course.

The study involves high school students (81) and biology students (33).

Results and conclusions. The necessity of serious scientific and pedagogical analysis of the innovation process at all levels of education to achieve effective management of the process and procedures of cognition has been *substantiated*. The paper *identifies the* problem of insufficient attention to the quality of digital educational content in the structure of e-learning courses, and the lack of special studies of this quality from the position of the student as a subject of the educational process. It is *proposed to* consider the educational potential of an e-learning course as a holistic construct with specific key characteristics as the main factor of content effectiveness. The value and importance of two characteristics - visualisation of properties, states of objects and processes; and demonstration of processes in dynamics with the possibility to manipulate them in a game experimental mode for the qualitative process of assimilation of complex for perception and presentation of educational material is *specified*.

The analysis of objective reasons for the increasing dynamics of the process of visualisation and demonstration of visibility is presented. It is proved that the effect of visualisation and visibility of educational content on difficult to understand educational material influences the result of its learning. The authors have proposed indicators of the effectiveness of visualisation and visibility techniques, as well as a set of criteria for its evaluation in the real use of an e-learning course in blended learning technology; the effectiveness of indicators and criteria for evaluating the visualisation and visibility of an e-learning course as significant characteristics of its educational

potential in the conditions of blended learning models in schools and universities has been substantiated and verified.

Keywords: educational potential, visualisation, visibility, electronic educational content, electronic educational course.

Introduction

Modern approaches to the organisation and implementation of the educational process at all its levels are focused on the predictive model of development. Rapidly changing political, economic and social trends oblige the education system to conduct innovation policy, to the dynamic introduction and use of modern methodological and technological tools of teaching, education and personal development. At the same time, the innovation process itself should be considered as an object of serious scientific and pedagogical analysis and management [48]. Recent events in education show that if the innovation process is subjected to the awareness of the whole palette of innovative actions, assessment of their positive and negative (risky) aspects, as well as the search for options for levelling or at least compensating risks, it is possible to visibly observe a certain main line of innovation, to systematically study and correct its individual links. E-education [49] can be considered as one of such volumetric main lines.

To date, scientific disputes over the definitions of "e-education" and "e-learning" have subsided, the professional teaching community has agreed with its interpretation, which is outlined by the following characteristics: it is a format (form) of educational activity, in which students have access to learning materials via the Internet; it is dominated by interactive and independent activities; it (the format) involves specially created educational infrastructure, including online courses, tasks, etc

E-education has entailed the process of digitalisation of educational activities and the development of complementary educational technologies. This is pointed out by both educators and psychologists researching educational issues [2-5]. "Digitalisation of education seems to be a very real process today, actualising more and more new problems for the pedagogical community. Already at present, informatisation and digitalisation of education have led to profound changes in the educational sphere of the country", educational researchers note [6]. In particular, the issue of developing digital educational content, i.e. educational and other information resources, materials presented in digital form and used in the digital educational space, is becoming increasingly relevant [7]. The most promising for large-scale and regular use of digital content seems to us the technology of blended learning [8, 49], to which the works of Samoilenko (2019) [10], Chernigovtseva et al. (2021) [11], Andreev et al. (2022) [9], Rvacheva et al. (2022) [12], Yan and Fedotova (2022) [13], and Amirova et al. (2022) [14] are devoted.

Obviously, against the background of the development of these processes, new problems and challenges are revealed. Thus, a team of scientists from St. Petersburg [15] emphasises the problem of the lack of standard approaches to digital educational content, although there are certain developments in solving this problem. Back in 2011, the Department for the Development of

Information and Communication Technologies of the Ministry of Education and Science of the Russian Federation developed a document called "Uniform Requirements for Electronic Educational Resources". Similar documents were issued later, both at the level of governing bodies and at the level of individual universities. As their content analysis shows, most of such recommendations are normative in nature. The psychological, pedagogical and specifically didactic side remains insufficiently elaborated and highlighted. At the same time, not only the questions of content - "what to teach?", but also the question "how to teach?" remain important for teachers, and in e-education the question "how?" acquires other outlines and other scales, additional methodological accents appear, which should take into account the nuances of information perception.

In 2020, the University of Innovation and Telecommunication Systems (Kazakhstan) developed rules for the design of educational content, which include psychological and pedagogical aspects of its preparation, including motivation, setting a learning goal, creating prerequisites for the perception of educational material, recommended formats for different types of information, general recommendations for the design of pages of educational content and the presentation of information on these pages [52]. However, we have not come across detailed recommendations or examples of the most successful combination of all these aspects, nor comprehensive studies in this context.

We believe that every author or author's team, creating didactic resource in the form of educational content, strives to achieve its maximum efficiency. The question of factors that ensure such efficiency, in our opinion, requires special study, and is not the subject of this study. We believe that the speed, level and depth of learning material, as well as the emergence of students' sustained interest in what is being studied, the desire to learn more about the topic can affect the right of didactic content to be included in the educational process of schools and universities [49, 50].

The factors of content effectiveness proposed above and left by us "out of brackets" should be considered comprehensively, the degree and qualitative characteristics of their interaction should be brought to the level of a system, in this regard, educators should agree on a generalising definition, the content of which can vary depending on specific goals, but remain unchanged as a holistic construct. We propose the concept of "educational potential" as such a construct. Its perspective and verifiability are convincingly reflected in the works of Epanchintsev A.O. (2010) [16], Nabiev (2015) [17], Shafikov (2019) [18], Lee et al. (2021) [19], Orynbet et al. (2023) [20]. The conciseness of this concept, its constructiveness, level of generalisation and flexibility of use, the possibility of its analytical study, in our opinion, quite meet the goal.

The educational potential of an e-learning course (hereinafter - ELC) should be subjected to scientific pedagogical analysis as a holistic, systemic entity, and its individual elements - as subsystems with the following key characteristics:

- quality at all levels of education;
- mutual coherence between the content of the ESC and the content of the main textbook;
- reliance on the regularities of students' cognitive activity at each stage of their age-related mental development;

- orientation of EQA to arouse interest, surprise, desire to know and understand more, to make learning material entertaining and promising for use both in everyday life and in future professional activities;
- reflection in the EOC of the leading provisions of science development, its development prospects, production technologies corresponding to it, as well as the concept of formation and development of the personality of a citizen of the country;
- optimisation of the content and methods of knowledge assimilation and skills formation;
- visualisation of properties, states of objects and processes, possibility to manipulate them in a game experimental mode;
- demonstration of processes in dynamics.

These characteristics are not presented here as a complete list. We pay special attention to the last two, and they have been singled out in accordance with the fact that two trends have become clear in the everyday and specially organised human worldview, particularly in the pedagogical process. The first is that the world is being visualised, facilitated by new digital technological possibilities; the second is that the information load on the human being in general, and on the learner in particular, is increasing. And if the second trend in the education system has been significantly developed (textbooks of 500-600 pages, teaching and methodical sets and complexes, which are a mini-library for each individual subject, are an illustrative example!), the situation with visualisation is not so good, as breakthrough solutions and achievements in this area are directly related to the technological and technical aspects of the educational environment, as well as the level of qualification of teachers - authors of content [16-20].

We believe that the dynamics of the process of visualisation, demonstration of visibility will increase, objective reasons contribute to this, let us name some of them.

1. Visualisation in mass consciousness is considered as a value, it is a trend of our time. The visual channel of perception in the worldview of many peoples was considered as a priority, which is reflected in mass culture. Anxiety of teachers and parents about the difficulty of assimilating educational information that contains hidden processes inaccessible to human perception is a thing of the past. The focus of anxiety has shifted to those subjects that predominantly use abstract thinking, for example, mathematics, which is reflected in the results of the USE. At the same time, we consider it important to note that in the curriculum of general education schools most of the positions are represented by those subjects that use both abstract and object thinking, for example, physics, biology, geography and others. For example, when studying biology, there is a gradual transition from the study of subject objects to subject-abstract objects, i.e. those that occur in real nature and cannot be observed with the naked eye. But they can be visualised, thus achieving continuity in the intellectual techniques of learning activity - the habit of thinking in visual categories, formed in primary school, has a continuation at further stages of both general and vocational education. This process requires taking into account the universal laws of perception discovered and described by psychologists, and developers of educational content should use the principles and regularities of the influence of a visual series on a person's conscious perception.

2. The level of expectations and prospective goals of the main consumers of educational content are different, which obliges to achieve qualitative adequacy of educational materials for different categories of students, in particular, through the visualisation of information units. Visualisation provides not only the formation of an objective picture of the world, but is also the main mechanism for the development of visual thinking, which is of particular importance at the stage of professional education. Visual thinking operates with visual images and generates new visual forms that carry meaning and make meaning visible. It is a special integrative type of thinking, which is based on creative imagination and combines the features of productive perception and visual imaginative thinking (R. Arnheim, V.P. Zinchenko).

3. The use of visual forms in the process of cognition, understanding and assimilation of educational information allows changing the nature of cognitive activity, giving it acceleration, deepening, stability, going beyond the limits of the cognisable here and now. According to psychologists, new information is learnt and remembered better when knowledge and skills are "imprinted" in the system of visual-spatial memory. Consequently, the presentation of educational material in a structured form allows faster and better learning of new systems of concepts, ways of action [21-23]. Visualisation as a methodological technique is constantly in the field of view of pedagogical scientists, methodologists, and practitioners. At different times, the pedagogical community was offered breakthrough works in this direction (for example, V.F. Shatalov's reference schemes), brought to the technological level.

Visualisation of objects, processes, events should be considered as a special art. Not everything can be visualised. If it is possible to visualise many objects in their real reality, processes - not all, and not always, due to the peculiarities of their dynamics or technical impossibility. Then modelling comes to the rescue, which is also considered by scientists as a way of visualisation. The responsibility of developers of training courses, textbooks, teaching aids, content materials is aggravated by the fact that incorrect or truncated information presented in visual aspect distorts or restrains the process of cognition.

Speeding up or slowing down a particular process, for example, the process of cell division through the technique of visualisation can mislead the student. We believe that not every biology teacher can correctly answer the question - how fast does cell division occur?, i.e., how much time passes from... and up to.... (in seconds, minutes, hours, etc., in time intervals that are familiar to the student). It is important for the formation of world outlook, as a human being lives in the conditions of space-time continuum, and the formation of the sense of reality, although not yet the subject of scientific and pedagogical analysis, plays an important role.

4. There is an increase in methodological and methodological literacy of educational resource developers. This is explained by the openness and accessibility of almost any content for analysis and criticism. Today there is no objection to the opinion that we should distinguish the concepts of visualisation and visualisation. Verbitsky (2016) understands the process of visualisation as "...the convolution of thought content into a visual image; being perceived, the image can be unfolded and serve as a support for adequate thought and practical actions" [24]. [24]. This definition allows us to separate the concepts of "visual", "visual means" from the concepts of

"visual", "visual means". In the pedagogical meaning of the concept "visual" is always based on the demonstration of specific objects, processes, phenomena, presentation of a ready-made image given from the outside, rather than born and borne from the internal plan of human activity. Unfortunately, the "educational cinema" industry, once actively developing, has now lost its traditions. Today we are in an era of "visual chaos".

We believe that it is promising to use both visualisation and illustration as methods of presenting educational material in E-Learning resources, combining them. This will help to discipline thinking and avoid methodological errors when investigating the degree of content effectiveness.

Teachers working on the problems of visualisation and visibility of didactic blocks of educational information offer for consideration and scaling their own experience of using a number of methodological techniques based on the psychological features of thinking, its stadiality. Among the most popular visualisation techniques are the following: mental maps (visual coordinate system, google map, scribing, cluster, reference scheme, crossens, and phonospectrogram. [25-26].

The use of the above-mentioned techniques is relevant when studying the material of biological disciplines and especially genetics. Having extensive experience in teaching genetic disciplines, the authors rightly argue that genetics is currently the most dynamically developing field of knowledge, and visualisation and clarity of processes occurring at the molecular level increases the accessibility of material perception. The reason for the relevance of studying genetic disciplines in universities and the genetics section in school biology is undoubtedly that today the development of domestic genetic technologies is among the key priorities of scientific and technological development of the Russian Federation. The modern view of the role of genetics is supported by the idea that it ensures the unity of biological sciences and the progress of such scientific areas as human and animal behaviour, ecology, sociology, psychology, medicine, etc., and becomes the methodological basis for studying and solving global problems of mankind through gene editing, gene vaccination, gene therapy, etc. That is why teaching genetics in schools and universities requires digitalisation of the educational process, use of modern approaches and digital tools to increase the accessibility of information and the level of independent participation of students in learning new knowledge, acquiring skills and abilities in the formation of professional competencies.

In general, we believe that working with large amounts of information or with material of high level of detail and complexity promotes the development of special methodological techniques of "compression" and "unpacking" of educational information within the framework of didactic visualisation. It also contributes to the development of the pupil's ability to generate new visual images and verbalise them. This work is most successfully carried out in various models of blended learning, as students receive part of the information independently on the basis of ready-made digital content, and have the opportunity to present and discuss the acquired knowledge in the course of contact work with the teacher and other students, deepening and consolidating what they have learnt.

The aim of the research: to substantiate and verify the effectiveness of indicators and criteria for assessing the visualisation and visibility of an e-learning course as significant characteristics of its educational potential in the conditions of blended learning models (in general and vocational education).

As a *working hypothesis we* accepted the position that 1) the effect of visualisation and visibility of educational content on difficult-to-understand educational material influences the result of learning, 2) it can be measured and evaluated by means of a certain group of criteria 3) in the course of measurement and evaluation, both the list and the content of significant criteria are inevitably adjusted.

Materials and Methods

Our position is that when creating e-learning courses today, one should move not "outwards", creating more and more new versions, but "inwards", assessing the degree of its effectiveness according to a certain set of criteria to be identified.

The study was conducted in two stages. The first stage was devoted to identifying the level of effectiveness of the e-learning course "Genetics for All: Just About Difficult Things" in general and assessing the performance of schoolchildren and students after its completion. The results were published in the scientific press [27]. The second stage involves the element-by-element evaluation of the educational potential of the developed e-learning course.

The study was conducted in 7 types of educational organisations at the general education level (schools with in-depth study of a number of subjects, individual training schools, public schools, secondary general education schools, basic general education schools, lyceum and gymnasium) and M. Akmulla Pedagogical University of the Republic of Bashkortostan. M. Akmulla Pedagogical University of the Republic of Bashkortostan. Pedagogical methods (theoretical analysis of pedagogical sources, meta-analysis, methods of observation and self-observation, comparison, targeted survey, interview, expert evaluation) and mathematical (ranking) research methods were used in the course of the work.

Research Design

The main stage of the study was carried out in March-April 2022-2023 (data collection), March-July 2023 (data processing, correction of the e-Learning content). Analysis of the results of the application of the electronic educational content "Genetics for All: Just about Complex" in the conditions of a flexible model of blended learning was carried out in order to verify the effectiveness of visualisation and visibility techniques used in it in the implementation of the chosen model of blended learning.

The research was carried out according to the following algorithm: comprehensive analysis of visual solutions and methods of presenting educational material in existing training courses for high school and college students, creation of the training course "Genetics for All: Simply About Complex", testing its effectiveness at the level of high school and college students, collection of information about its adequacy to educational tasks and peculiarities of students' perception, identification of significant criteria, creation of methodological recommendations for teachers developing e-learning courses.

The electronic educational course "Genetics for All: Simply About Complex" for schoolchildren and parents includes 5 modules: 1) DNA - the main molecule of life; 2) Genes and genomes: how

everything is organised; 3) Genes are to blame for everything: basic principles of heredity; 4) What are mutations and why do they occur?; 5) Science of the future: what modern genetics can do. The aim of the course is to raise the educational level of schoolchildren in the field of genetics and related disciplines, to develop creative abilities, to get acquainted with genetic technologies, practical and research application of new knowledge in genetics, to form motivation to choose specialities of biological profile. Involving parents in the study of the course together with children strengthens the emphasis on the discussion within the family of the inheritability of certain phenotypic traits in generations of relatives, including abilities and predisposition to diseases, prevention of their occurrence and other important aspects that make up the health of the family and the nation as a whole, motivates to a healthy lifestyle.

The electronic educational course for teachers and students as future teachers consists of 6 modules: 1) Organisation and functioning of genomes; 2) Genetic combinatorics - the key to phenotypic diversity; 3) Laws of heredity; 4) Variability of organisms; 5) Population genetics; 6) Modern genetic technologies. This course is aimed at improving the educational level of current teachers and students in the field of genetics and related disciplines, generating interest of teachers and students in studying modern genetic technologies, creating new teaching and methodological developments and new educational technologies for teaching genetics and general biology in secondary schools.

Characteristics of the educational courses

The main characteristics of the courses are universality and comprehensiveness; the possibility of studying the modules in any order (no rigidly defined sequence), which makes it possible to use them in academic and extracurricular activities of students and in the course of independent work; a high index of integration of the course into any biology work programme of general and professional education, which provides the possibility of building an individual learning trajectory; high practical significance of the course, since the knowledge of inheritance

For better visualisation, the didactic material of the course includes video materials with elements of animation. All modules are designed in a uniform visual manner (colour scheme, background, size of basic information tools and units, duration of demonstration, presence of dynamics in presentation of elements, speed of change of information units, etc.).

Targeted survey

As the main method of data collection we used the method of self-completion of a specially designed questionnaire for 10th grade pupils (81 respondents) and students (33 respondents), which was placed in Yandex forms. Data processing of the conducted survey was carried out using Microsoft Excel package.

The content of the questionnaire was developed by an expert group including biology teachers from urban and rural schools and genetics teachers from higher education, working with blended learning technology and using the proposed e-course. The questions presented to learners were closed-ended with one or more answers selected from a list, open-ended with a free response (one sentence or paragraph); and mixed-ended with the possibility to make a suggestion to adjust the visual range of the content depending on the context of the question-answer.

We have chosen the following as ***indicators of the*** effectiveness of visualisation and visibility techniques used in it when implementing the chosen model of blended learning:
- optimality of the duration of one fragment while presenting information within a strictly limited range;
- sufficiency of the "size range" in drawings and diagrams;
- ease of navigation;
- the quality of the colour design of the course (as a whole and its individual elements);
- realism of the depicted objects;
- special effects;
- the speed of the video sequence and the pace of the speakers' accompanying speech;
- motivational factor (desire to return to watching, positive associations, actualisation of interest, etc.).
- the strength of visual images and their recognisability in other sources.

The selected indicators were "packed" into twenty-four questions of different types (open, closed, mixed). When processing the results, the answers were grouped into blocks according to the principle of composing the characteristics of content visualisation and visibility, and five criteria were highlighted (Table 1).

Table 1.

Criteria for visualisation and visibility of content

№	Criterion	question no.
1	Solid learning of complex, inaccessible to real-world observation of learning material	1
2	Duration of the study fragment	2
3	Size and colour design of the objects to be presented	5,6,7,8,9,10,11
4	Navigation system and special effects	3,4,12,13
5	Motivation (interest, positive associations, ideas, desire to learn more)	14,15,16,17,18,19
6	Recognisability of objects in other media	20

Research Data Processing

Analysis of answers to the questionnaire was supplemented with information obtained from respondents during personal interviews. Statistical processing of data was carried out both manually and with the help of the software package "Statistica".

Results

The conducted study confirmed all three parts of the working hypothesis.

The first task

We were convinced that the effect of visualisation and visibility of educational content on such a difficult to understand and assimilate educational material as genetics from the point of view of students (schoolchildren and students) influences the result of assimilation. This hypothetical statement

was confirmed by 97.368% of the respondents (data were rounded to thousandths). During the personal interview we received the following statements to confirm this point of the hypothesis (we quote verbatim): "We are the generation of seeing, the picture is important for us...", "It is easier to look and see than to listen, and if the picture is bad, you don't want to look...", "The quality of the video clings..., or doesn't cling..., this is how you can learn...", "You understand better when you see it in real life...", "Finally understood after watching what they were talking about in class, it turns out to be cool interesting! Is it really like that?", "I watched it, I understood it, now I won't forget it" and so on in a similar vein. To the direct question: - "Does it...?", the answer is unambiguous: - "Yes, it does!". The remaining 3 people (2.632%) could not make up their minds, their answers "floated" in the categories "probably", "maybe", "not excluded". We are aware of the fact that at first glance the obtained result is obvious, however, in this question, as psychologists interpret, not everything is so unambiguous due to the peculiarities of perception in specific categories of people (visualists, auditoryists, kinesthetes). We are also far from thinking that all 111 people who unambiguously determined the answer belong to visualists, but the obtained data show that the effect of visualisation and visibility of educational content affects the result of learning (criterion №1 in Table №1), and this is the confirmation of our first hypothetical statement.

The second task

The effect of visualisation and visibility of educational content can be measured and evaluated by means of a certain group of criteria. We have identified the criteria, the meaning and axiology of which are conditioned by the laws of visual perception, they are presented in Table 1 under numbers 2,3,4,6. The survey showed that:

- the majority of respondents (out of the total number of pupils and students surveyed) would like to see educational content in the amount of 15-20 minutes (65.789%), we also took into account the opinions of those who are ready to perceive it in the amount of 10 minutes - 7.017%, in the amount of 25 minutes - 8.771%;
- the degree of satisfaction (expressed in points) with the size and colour design of the presented objects was generally rated by pupils as above average. Pupils rated this indicator as five points (54 pupils) and four points (27 pupils). For content developers, this indicator was categorised as needing adjustment. The same question for each module separately confirmed the need for adjustment, with three people giving a "satisfactory" rating for modules 3, 4, and 5. Students were more stringent in their assessment of the colour design and size of the objects presented. Most scores were in the five and four point range, with more five point scores, but three point scores were also found, one respondent rated this content criterion at 2 points. Respondents' attitudes were clarified in the face-to-face interview. Among the positively assessed elements were the colour scheme of the background, bright pictures, the pace of presentation, the articulation of the speakers, the consistency of what was said and presented visually, the "visible" level of competence of the teachers, their confidence and didacticism. Of the verbally expressed evaluations, the most frequent are "easy to perceive because there is nothing superfluous...", "nothing distracting, not annoying...". Among the questionable elements (and this influenced the

evaluation) - the size of drawings and models, as well as the text in them, the speed of change of drawings;

- In terms of the criterion "navigation system and special effects", we received a rather homogeneous picture in the answers, which was expected from the point of view of the developers of the training course. The following answer options were offered to the direct question "Is the navigation and control system convenient enough?": "yes, it is convenient", "in general, it is convenient, but some changes are required", "no, it is inconvenient": "yes, convenient" - 69 (people), "generally convenient, but some changes are required" - 4 (people), "no, inconvenient" - 0 people; students: 27/6/0 (people) respectively. When asked to suggest changes to the navigation and control system, students reacted neutrally, answering that "everything is good, no changes are needed"; students suggested adjusting the possibility to "return to the main screen after viewing the test", "give more drawings, diagrams". The answer to the question "Do you think it is necessary to use special effects in this course?" implied choosing the answer from the options: "yes, it is absolutely necessary", "it can be used, but it is not necessary", "I do not care, it does not affect learning", "it is not necessary, but if it is "fun" for someone, it is possible", "it is not necessary at all, it is distracting". Here we give the number of elections in the same order; schoolchildren - 12/36/21/6/6 (people), students - 6/14/8/3/2 (people). The above choices show a tendency towards special effects, they are not obligatory, and we note with satisfaction that our choice not to use special effects was correct, while we were guided by the idea of concentrating students' attention on the teaching material. Both pupils and students noted that even if the content was not loaded with special effects, they often had images, memories, associations and ideas while watching it; this effect was noted by 79 pupils and 32 students. Based on the conducted survey, we consider it promising to include the criterion "navigation system and special effects" in the system of evaluating the effectiveness of visualisation and clarity of the educational content of an e-learning course;

- recognisability of objects on other media, in our opinion, proves the reliability of the fact that the material is learnt. To the question "After watching this training course, will you be able to easily identify the objects you have studied (DNA chain, cell, cell nucleus, etc.) when you see them on other media - books, posters, slides, banners, etc." the answers of schoolchildren were distributed as follows: yes, I can without strain - 45 (people); I am not sure that I can - 33 (people); I cannot - 3 (people); students - 24 (people), 8 (people), 1 (people) respectively. We did not carry out a special test for recognisability of objects, we were interested in the degree of confidence of respondents, and it as well as motivation depends on different factors. However, we confidently included this criterion in the evaluation system we developed.

Motivation occupies a significant place in our proposed system. The level of motivation for independent learning is reflected in the answers to a number of questions in our questionnaire. At the same time, the questions were not asked directly, but were proposed in the following constructions: "Did you have a desire to revise individual modules or the whole course again? How many times?", "After reviewing the content, do you have a desire to learn more about the topic, listen to and watch additional materials?", etc. There was also a question on negation, for example,

"After watching the first module, do you have a desire not to watch further?". The result of data processing showed a rather high degree of motivation, more than 76% of the total number of respondents expressed the desire to return to watching the course, to refer to additional materials, other sources. It is obvious that the motivational component of the cognitive process, especially in the format of independent work is a complex, multidimensional phenomenon, but it indirectly confirms the successful solutions in the demonstration of visual and illustrative images.

Discussion

Information saturation of modern educational environment in recent years is considered as the most important factor in achieving high quality education. This is indicated by numerous researchers dealing with the problems of educational environment organisation, identifying its components and effects [28-33]. The effects arising in the process of informatisation of the educational environment of a higher education institution and influencing the quality of students' training are considered by Noskova et al. (2016). The authors, highlighting the effects of information saturation, spatial and temporal freedom of educational interaction between teachers and students, the possibility of implementing individualised information and communication educational request, note that in order to more fully unlock the potential of the electronic educational environment and provide greater guarantees of obtaining quality educational results, it is necessary to improve both corporate strategies for the development of the university's information environment and the introduction of e-learning. An important direction in the presented research is defined as the achievement by teachers of special competences that provide the possibility of forming a diverse and adaptive media-rich environment. The authors point out the need to take into account the peculiarities of subjects' cognitive activity and their modalities of information perception [34]. This agrees with our research in terms of the adaptability of digital information materials to their perception by students and with our research position - this problem should be given special attention when developing digital information products such as simulators, video clips, text resources, etc. The authors point out the need to take into account the peculiarities of subjects' cognitive activity and their modalities of information perception [34].

The didactic principle of information saturation of the educational process requires the correct preparation of educational material, which is the responsibility of the teacher (developer), it is especially relevant for its presentation in electronic format, because depending on the quality of didactic techniques of visualisation and visual presentation of difficult to perceive educational material depends on the level of activation of thinking and cognitive activity of students [50, 51]. We find similar reasoning in the work of Zhelezovskaya et al. (2017). Discussing the new qualities of the educational process in the information space, the authors conclude that when preparing for the lesson, the teacher should take into account the availability and effectiveness of the information presented in any form. The volume and content of the teaching material should be within the student's capabilities, and it is necessary to take into account the correspondence of the level of his/her mental development and the available stock of knowledge, skills and abilities [35]. At the same time, it should be remembered that it is necessary to take into account some universal laws

of human perception, as it is hardly possible to focus on the individual characteristics of each student today; while we are in the paradigm of mass (collective) learning [50].

Independent work of students, the level and volume of which today is rapidly growing not only in professional but also in general education, involves the study of large, multi-level, complexly organised, detailed information sources, which requires special methodological work that requires "compression" and "unpacking" of educational information within the framework of didactic visualisation. The very principle of didactic visualisation is considered by teachers as a natural development of those principles of learning, which were once described in his works by J.A. Comenius - the principle of visibility, the principle of accessibility, the principle of connection between learning and life [36-38]. Issues related to didactic visualisation of educational information are widely considered in the scientific press, including the functions of visualisation tools of educational texts, their brief characteristics, the techniques of "encoding" and "decoding" are outlined in the work of Smolnikov (2023) [39]. Some psychological and pedagogical aspects of creating electronic didactic materials, as well as the principles of taking into account the psychophysiological characteristics of students and psychological and pedagogical ergonomics of methods and technologies for visualising learning content in electronic didactic materials are presented in the study by Inozemtseva and Kuzhekin (2017) [40]. The authors express concern that "Errors that distort adequate perception of information are determined by several groups of factors, namely: - The level of individual sensitivity of the corresponding analysers (sense organs); physical characteristics of signals: their intensity, duration, periodicity, separation or simultaneity of influence, etc.; personality characteristics: functional state, professional preparedness, level of motivation, presence of psychological and physical limitations; the degree to which electronic learning tools take into account the psychophysiological characteristics of the learner in terms of information perception". Such shortcomings, they point out, require the improvement of visualisation of learning content in electronic didactic materials. The authors propose to consider two main principles of visualisation of educational content in electronic didactic materials - the principle of taking into account the psychophysiological characteristics of students and the principle of psychological and pedagogical ergonomics, and in this context they propose the following list of parameters for analysing the visual image in the process of perception: colour, font, contours of objects, scale, space and perspective, movement of elements, graphics [40].

The activation of students' cognitive activity by means of visualisation techniques and methods is mentioned in the works of Manko (2009) [41] as well as Titova and Zamkova (2022) [42]. The techniques of visualisation of educational material in the context of school and university teaching have been widely studied [43,44]. A number of works proposed to consider visualisation as an element of didactic potential of educational information [45-47]. In contrast to previously published studies, we have come to the conclusion that the integration of visualisation and visuality contributes to the development of the student's ability to generate new visual images and their verbalisation, which we have tested in various models of blended learning. The technology of blended learning itself and the use of its various models in the educational process of schools and universities, in our opinion, contributes to the development of skills to present independently

obtained by the student "products" of his/her learning activity - projects, their description and presentation materials, reports, cases, posters and schemes. Some of the information students receive independently on the basis of ready-made digital content, therefore, specially designed e-learning courses, the content of which is coordinated with the main educational programme, specify certain topics, supplement them, perform motivating, activating the process of thinking and assimilation and career guidance work, become especially important.

An e-learning course is an author's methodological product, which should have a sufficient level of efficiency. In the course of our work we have identified and substantiated the problem of insufficient attention to the quality of digital educational content in the structure of e-learning courses, and the lack of special studies of this quality from the position of the student as a subject of the educational process. We have proposed to consider the educational potential of an e-learning course as a holistic construct with specific key characteristics as the main factor of content effectiveness. We consider visualisation of properties, states of objects and processes and demonstration of processes in dynamics with the possibility to manipulate them in a game experimental mode to be particularly significant. The quality of the process of assimilation of difficult to perceive and present educational material in the course of its independent study depends on them to a high degree.

Conclusions

The process of visualisation is consistent with the modern tradition of organising cognition and intellectual development of a person, it is a familiar and comfortable way for a student to learn new things, and our research shows that the effect of visualisation and visibility of educational content on difficult to understand educational material affects the result of learning. We have proposed indicators of the effectiveness of visualisation and visibility techniques, as well as a set of criteria for its evaluation in the real use of e-learning course in blended learning technology, ***substantiated and tested*** their effectiveness in the conditions of secondary school and teacher training university.

Based on the results described above, we believe that additional studies of this kind can lead to some adjustment of the set of criteria and indicators for assessing the visualisation and visibility of an e-learning course, and their effectiveness in general. We consider it important to note that the features of visualisation and visibility could be compensated by direct communication with the teacher or instructor. This is an important remark from the point of view of achieving the required level of assimilation, as it obliges educational content developers to be in close co-operation with practicing teachers.

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