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Определение интегрального показателя здоровья школьников на основе инновационных технологий

Введение. Здоровье школьников является фундаментом для образовательного процесса и залогом успеха в будущей трудовой деятельности. Современный уровень развития техники и информационных технологий позволяет вывести мониторинг здоровья на новый более качественный уровень.

Цель исследования: на основе сопоставления различных исторически сложившихся подходов к оценке здоровья школьников, выявить основные тенденции развития и перспективные технологии, пригодные для определения интегрального показателя здоровья школьников.

Методология и методики исследования. Исследование носит теоретический характер. Для поиска информации об инновационных технологиях мы анализировали научные статьи на русском и английском языках, взятые из наукометрических баз. В результате нами были выбраны 14 технологий, которые в большей степени соответствовали требованиям минимальных времязатрат, дистантности и инвазивности.

Результаты. Технологии, используемые в биомеханике, медицине, криминалистике, навигации в совокупности могут позволить комплексно оценить психологический, нейродинамический, двигательный и энергетический компоненты здоровья школьников. Наиболее перспективными для оценки здоровья школьников являются следующие системы: система обработки изображений (технология обнаружения и распознавания лиц, технология распознавания мимики лица и жестов), оптико-электронной измерительная система (технология захвата движения), система внутренней термометрии (акустотермометрия), навигационная система, электромагнитная измерительная система, система контент-анализа интернет-трафика, тензодинамометрическая система, а также нейротехнологическая система. Предлагаемый подход требует существенных информационных ресурсов для накопления и автоматизированной обработки больших объёмов информации в едином аналитическом центре. Применение алгоритмов искусственного интеллекта позволит обнаруживать скрытые взаимосвязи показателей здоровья, оценивать риски и давать персонализированные рекомендации.

На основе собираемой информации предполагается создание электронного паспорта здоровья школьников с дальнейшей интеграцией данного модуля в отечественный образовательный комплекс электронного дневника школьника.

Ключевые слова: здоровье, школьники, интегральный показатель здоровья, технологии, мониторинг, тестирование, паспорт здоровья, измерительные системы, Big Data, Data Mining

Ссылка для цитирования:

Померанцев А. А., Старкин А. Н., Червякова Е. В. Определение интегрального показателя здоровья школьников на основе инновационных технологий // Перспективы науки и образования. 2021. № 6 (54). С. 257-270. doi: 10.32744/pse.2021.6.17

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Assessing the integral health indicator of schoolchildren on the basis of innovative technologies

Introduction. The health of schoolchildren is the foundation for the educational process and the key to success in future work activities. The current level of development of technology and information technology allows you to bring health monitoring to a new, higher quality level.

Purpose of the study: on the basis of a comparison of various historically established approaches to assessing the health of schoolchildren, to identify the main development trends and promising technologies suitable for determining the integral indicator of the health of schoolchildren.

Research methodology and techniques. The research is theoretical. To search for information about innovative technologies, we analyzed scientific articles in Russian and English, taken from scientometric databases. As a result, we selected 14 technologies that were more consistent with the requirements of minimum time consumption, distance and invasiveness.

Results. Technologies used in biomechanics, medicine, forensic science, navigation together can make it possible to comprehensively assess the psychological, neurodynamic, motor and energy components of schoolchildren's health. The most promising systems for assessing the health of schoolchildren are the following systems: an image processing system (technology for detecting and recognizing faces, technology for recognizing facial expressions and gestures), an optoelectronic measuring system (motion capture technology), an internal thermometry system (acoustothermometry), a navigation system, an electromagnetic measuring system, system of content analysis of Internet traffic, strain-dynamometric system, as well as neurotechnological system. The proposed approach requires significant information resources for the accumulation and automated processing of large amounts of information in a single analytical centre. The use of artificial intelligence algorithms will allow detecting hidden relationships of health indicators, assessing risks and giving personalized recommendations.

On the basis of the information collected, it is planned to create an electronic passport of schoolchildren's health with further integration of this module into the domestic educational complex of an electronic student's diary.

Keywords: health, schoolchildren, integral health indicator, technology, monitoring, testing, health passport, measuring systems, Big Data, Data Mining

For Reference:

Pomerantsev, A. A., Starkin, A. N., & Chervyakova, E. V. (2021). Assessing the integral health indicator of schoolchildren on the basis of innovative technologies. *Perspektivy nauki i obrazovaniya – Perspectives of Science and Education*, 54 (6), 257-270. doi: 10.32744/pse.2021.6.17

Introduction

The term "health" and understanding of the relationship between health and environmental factors have continuously changed throughout history, and have significantly transformed along with scientific and technological progress. Science, step by step, discovered the capabilities and functions of our body: from the role of genes and the structure of proteins to understanding the role of society in maintaining health.

Currently, the final concept of "health" has not been developed yet. This indicates the complexity of this phenomenon and its multifactorial nature. I.I. Kalju, based on various classification signs, gave 79 different definitions of health. Below are the main definitions of this concept [5]:

- the natural state of the body;
- balance with the environment;
- high efficiency of the immune system;
- absence of any pathologies;
- sufficient functional performance of various organs and systems;
- adaptability.

One of the historical approaches to assessing health status has been the opposite approach. Disease was the antipode of health. Since health and illness are mutually exclusive phenomena, the quality of health was the indicator of the absence of illness. Nowadays, this principle is still used in some cases, for example, when determining indicators of group health based on statistics of child mortality or life expectancy.

There is no absolutely healthy person, and illness is not always a sign of lack of health. Disease is often a manifestation of an adaptive response of a healthy organism, which allows a person to return to an equilibrium normal state.

The most famous definition of the concept of "health" is given by the World Health Organization, according to which, health is a state of complete physical, mental and social well-being, and not just the absence of disease.

The difficulty of measuring health and expressing this quality in quantitative terms is a task that has yet to be solved by science. There is no unambiguous answer on what parameters to judge health, what assessment scales to use, how to correlate various parameters, as well as how to take into account the individual characteristics of a person and environmental factors.

The search for an integral indicator of health is the "Holy Grail" of modern human sciences. Most often, a medical approach is used, based on the analysis of such indicators as nonspecific resistance, general physiological reactivity, blood composition, metabolism, immunological reactivity.

The definition of an integral indicator of health is in some cases of practical importance, for example, when determining disability or assessing national health. Population or public health is an important indicator of the quality of life of people, the impact of the economic, environmental and demographic situation. Statistical data can be used as an integral indicator of population health: average life expectancy, infant mortality, percentage of the population with disabilities, and others [1].

In socio-economic studies, the indicator of life expectancy is adopted as the main integral indicator of population health; it is also used to calculate the human development index.

Assessment of individual health cannot be achieved by statistical calculations; therefore, it requires a more complex systematic approach.

Studying the phenomenon of health P.K. Anokhin, came to the conclusion about the well-coordinated interaction of mental, neurodynamic, energetic and motor components [3]. From the concept of the functional system proposed by him, it follows that for a complete understanding of the state of health, it is important not to assess individual manifestations, but to understand the nature and relationship of various indicators and components. Moreover, it is impossible to fully judge the state of health, evaluating it by one component or several tests.

A systematic approach to health assessment involves understanding the significance of each component, by choosing a valid and reliable assessment fund for measurements, using modern technologies, collecting a large amount of data, as well as using a powerful mathematical and statistical apparatus to analyze the relationship of health components.

The aim of the study was to form a new information-dynamic approach for the integral assessment of the health status of schoolchildren, based on modern non-invasive and distant technologies.

Materials and methods

The research is theoretical. The article describes and systematizes innovative technologies suitable for a comprehensive assessment of the health status of schoolchildren.

Research based on literary analysis. We used the databases Scopus, Web of Science, Google Scholar, RSCI, Cyberleninka. To search for information of interest to us, we entered queries using combinations of keywords: health, health of schoolchildren, modern medical technologies, modern biomechanical technologies, artificial intelligence in medicine.

The technologies under consideration were taken from articles in peer-reviewed journals or conference proceedings published in Russian and English [2; 4; 7-9; 11-15; 19; 21-31].

Of the many technologies found during the initial search, only those technologies that made it possible to assess the components of the integral indicator of schoolchildren's health without disrupting the pedagogical process were included in the final consideration.

Research results

We analysed the Russian and foreign experience of determining the integral indicator of schoolchildren health.

The overwhelming majority of domestic studies are based on tests aimed at identifying various components of health (see Table 1). Tests can be blank or instrumental solutions. According to the test results, a "health profile" is built or an integral characteristic indicator is found based on weight coefficients.

The article [18] analyses articles devoted to the foreign experience of the integral assessment of the health of schoolchildren, including 952 studies. The authors showed that all the works also used a variety of tests, and the emphasis was on the psychological component of health. Most often, questionnaires and tests were used to assess satisfaction with school meals, teacher-student relationships, desire to attend school, interpersonal relationships of schoolchildren, and their knowledge of health preservation. Thus, in foreign practice of studying the health of schoolchildren, firstly: subjective assessment methods

are also used instead of objective instrumental ones; secondly: the object of research, to a greater extent, is the collective health and the environment surrounding schoolchildren, and not their individual health [10].

Table 1

Variants of tests used to determine the components of health in the classical approach in the studies of Russian scientists

Health component	Tests
Mental	Bourdon's proof test Landolt's proof test Digital Grünbaum test Platonov's table Minnesota Multiple Personality Questionnaire Ketell test Eysenck test Test "Well-being, activity, mood" Spielberger test
Neurodynamic	Simple reaction time test Test for determining a complex space-time response Tapping test Electroencephalography Reoncephalography Determination of galvanic skin response Critical frequency of fusion of light (sound) flashes
Energetic	Power working capacity test (PWC-170) Margaria-Kalamen power test Letunov's test Cooper test
Motor	Determination of the anthropometric profile Tests for the determination of various motor abilities: strength abilities, coordination abilities, endurance, speed, flexibility.

It can be argued that the classical testing-based approach should be considered methodologically outdated, since it is time-consuming, not operational, and therefore not objective [3].

Speaking about the integral indicator of health, it should be understood that the state that it reflects is highly variable. A healthy person, after a moment, can become sick, due to an injury, infection or perception of negative information. Especially the dynamism of the concept of health is associated with psychological health – an important component of the integral indicator. It is a mistake to consider health as a static, slowly changing characteristic. It must be borne in mind that deterioration in health can occur in seconds, and recovery can take many years.

If the integral health indicator is used as an indicator in decision-making, it must be relevant and timely. Outdated data means indicators are biased and lead to erroneous conclusions.

Having studied the existing methods and identifying their shortcomings, we propose a new approach to a comprehensive assessment of the health of schoolchildren, based on innovative technologies.

The approach to determining health, in which the collection of data, the analysis of indicators is continuous and automated, and decision-making is minimally delayed from the moment of receiving the data, we called information-dynamic. The proposed approach requires modern technologies for assessing health components, most of which are classified

as non-invasive and distant, as well as information resources for the accumulation and processing of large amounts of information (Table 2). The information-dynamic approach implies a continuous automated search for personalized solutions based on the analysis of large amounts of data and the use of artificial intelligence [4].

Table 2

Comparison of Historical Approaches to Health Assessment

No	Indicator	Traditional approach	Information-dynamic approach
1.	Frequency of determination (updating) of health indicators	Low, at large intervals	High, continuous control
2.	Basis for assessing health	Tests	Diverse sensors and control devices
3.	Data for analysis	Single indicators	Large datasets in dynamics
4.	Analysis tools	Descriptive statistics	Data Mining Tools
5.	Analysis of the relationship of various indicators	No	Yes
6.	Prompt decision making	Low	High
7.	Time consumption	High	Low
8.	Automation of decision making based on health assessment results	No	Yes
9.	The possibility to use artificial intelligence	Low	High
10.	Number of indicators used to assess health	Insignificant	High

The modern information-dynamic approach is based on 7 principles:

1. Application of distant technologies. Distant technologies allow you to control the parameters of a student's health at a distance, without attracting attention to yourself and without interrupting the educational process.

2. Continuity of the educational process. The proposed approach minimizes the number of used (time-consuming) tests and allows evaluating health parameters in the background.

3. Continuous monitoring of health parameters. This principle assumes minimizing the time step for updating data on the child's health status. Ideally, data should be updated every minute.

4. Centralized data collection. Centralization of information flows implies continuous transfer of readings from all measuring systems to a single database, in which they are stored and analysed using Big Data technologies.

5. Process automation. The information-dynamic approach does not involve the operator in the normal mode. A person is only required to set up the system and improve the analysis algorithms.

6. Application of modern technologies for analysing large data arrays. To determine the relationships (complex, hidden) and forecasting, it is proposed to use artificial intelligence technologies and Data Mining tools.

7. Prompt decision making based on recommendations. The information and analytical system monitors the current state and trends of changes in health parameters. In the normal mode, the system generates individual recommendations for maintaining health, and when indicators deteriorate, it serves as the basis for making operational decisions.

The ethics of such an approach based on the collection of data, in this case, is beyond doubt, since national health is of paramount importance, and only the student himself and

his parents will have access to personal information about health, who has the right to transfer information to educational or medical institution.

Discussion of the results

To implement the information-dynamic approach in practice, innovative technologies were chosen that allow remotely, non-invasively, without spending time on testing, receiving continuous information about the health of schoolchildren (see Table 3).

The primary task of automated monitoring of human health is associated with face detection and recognition. Such technologies are the most well developed in forensic science and are already being used to preserve the health of citizens at the most important targets from the point of view of terrorist threats. Similar technologies are also used in banking systems for contactless payments.

The problem of detecting faces in a stream of people in real time can be solved based on various approaches and algorithms. Known: the method of distribution of control points, the method based on templates, the method of constructing histograms, the method of grouping features, the Viola-Jones method, and others. Factor analysis and neural networks can also be used in face search based on footage.

A more difficult task is face recognition in order to identify a specific person. The main method in solving such problems is the neural network method or similar methods based on trainable models. More than twenty similar methods are described in the scientific literature [30].

A person's face for the interlocutor is a source of a large amount of information, ranging from race, gender, age and ending with the psycho-emotional state at a particular moment in time. Such information is easily "read" by another person. The idea of the interlocutor is formed during the first few seconds of communication [14].

Currently, 3 main characteristics of a person's face are known that are suitable and informative for determining health: symmetry, averaging and severity of sexual characteristics [8]. It is not surprising that these same traits are factors of attractiveness to the interlocutor [17; 20]. The listed characteristics are amenable to algorithmization, can be determined, and also expressed in digital form using special programs.

Studies have shown that significant asymmetry of the face indicates poor nutrition, infection with parasites, genetic mutations, and therefore, reduces reproductive success. However, other studies based on mathematical statistics show that there is no significant relationship between health and mild symmetry [16].

Another indicator of a face that allows us to judge the state of health is its color [9]. An experiment with a shift in the colour balance towards yellow or red, as well as a change in illumination, leads to a change in the subjective perception of human health presented in the photograph.

A person's mood is an important dynamic indicator of health. Outwardly, this sign is expressed in the form of various manifestations of emotions through facial expressions. For the automated determination of a person's mood and his psychological state based on facial expressions, there are also groups of methods, the most promising of which are the Viola-Jones algorithm, the comparison method on graphs, the method of informative areas, various morphing models.

Table 3

Classification of modern information technologies for monitoring the health parameters of schoolchildren

Measuring systems	Technology	Controlled parameters	Health components	Notes
image processing systems	face detection technology	number of people in the lens		basic technologies for human identification
	face recognition technology	facial features, complexion, symmetry, averaging, severity of sexual characteristics	mental	
	face detection technology	displays of emotions	mental	
	technology for recognition areas of the face	pupil response to light	neurodynamic	high resolution shooting required at a short distance
	Kinect™	human posture, gestures	mental, motor	
optoelectronic measuring systems	motion capture technology	change in the position of the body in space, motor activity, the degree of mastery and the correctness of the fulfillment of movements, motor abilities, growth	motor, mental	without using markers
thermometry	magnetic resonance thermometry	temperature of internal tissues and organs	identification of pathologies and prevention of diseases	best spatial resolution
	Microwave radiothermometry			highest thermal sensitivity
	acoustothermometry			the ability to measure in an automated mode
electromagnetic measuring systems:	GPS-GLONASS-GALILEO	movement, physical activity	motor, energetic	based on GPS technology devices used by schoolchildren
	RFID	motion	motor, energetic	based on passive tags
content analysis of internet traffic	semantic analysis of search queries	human information field	mental	
tensodynamic systems	tensometry	static and dynamic weight, speed-strength abilities	motor component	rationality place the strain gauge platform in the gym
software-based neurotechnology	user-friendly software application	time of simple and complex reaction, critical frequency of fusion of light (sound) flashes, tapping test	neurodynamic	

Thermoregulation is an important aspect of homeostasis. Surface thermometry technology has been developed and applied for medical purposes since the 70s of the 20th century. Surface thermometry is currently being carried out in connection with the COVID-19 pandemic in all educational institutions and manufacturing enterprises.

The most promising technology for health monitoring is the technology of remote measurement of core body temperature. Measuring the temperature of internal organs and tissues can provide unique information for the diagnosis and prevention of various diseases. The deviation of the internal temperature from the norm precedes morphological changes, which can later be recorded using X-ray and ultrasound methods. For a long time, for medical purposes, the internal temperature was measured using a temperature probe, but this procedure is painful and traumatic.

Currently, there are already at least three technologies that allow non-invasive and distant determination of the internal temperature of the human body: magnetic resonance thermometry (MRI), microwave radiothermometry, acoustothermometry [2; 23]. The best spatial resolution is MRI method, the most developed method with the highest thermal sensitivity – microwave radiothermometry. However, the most promising within the framework of the proposed concept is the method of acoustothermometry, which makes it possible to measure the temperature of internal tissues remotely in an automated mode, without requiring any additional manipulations on the part of people [25].

The most important component of health in the information society is the psychological component. It is known that a modern person spends a significant part of his free time on the Internet. This is especially true for children and adolescents. In addition to filters that restrict a child's access to prohibited information, the technology of content analysis of Internet traffic is able to assess the level of mental health of a child based on his interests and time spent on the Internet [6].

The key parameter in understanding health is the quality and quantity of movements performed by a person. The motor and energy components of health are directly related to movements.

We assume it is advisable to use optoelectronic systems to control the parameters of movement throughout the entire stay in an educational institution, including lessons, changes, and in particular, physical education classes [11; 29; 31]. The approach based on automated movement recognition allows you to determine both the number of movements performed by the child and the quality of their performance. In the automated mode, it is possible to control the manifestations of strength, speed, endurance, flexibility, as well as coordination abilities [28].

Optoelectronic systems can easily determine the height of a child standing and sitting, the length of the limbs. Thus, in the automatic mode, it is possible to control somatometric indicators in the dynamics of their development. The weight of the child, in a similar way, can be determined using tensodynamometry.

Optoelectronic systems are the most accurate of all existing types of biomechanical systems for motion capture. The principle of operation of the optoelectronic measurement system is to register light (contrast) points to determine the 3D position of the marker [21]. The complexity and accuracy of optoelectronic systems depends on a number of components: the number and location of cameras, distance between cameras, characteristics of markers. In addition, the quality of the biomechanical analysis is influenced by the resolution of the camera and the frequency of shooting. Optoelectronic systems analyse images that enter the lens of video cameras. The biomechanical complex with the largest motion capture area can be considered the Vicon MX13 system, which is capable of detecting movements on 824 m². Such a huge area requires 24 cameras [19].

Optoelectronic systems are divided into two categories: marker (active and passive) and markerless. Passive markers reflect light back to the sensor. Active systems use markers,

which are the light source for sensors in a different range of the spectrum. Following the principle of automated registration and the absence of interference in the educational process, technologies without the use of markers are more suitable for solving the problem of determining health parameters [24].

The GPS-GLONASS-GALILEO system will be used to determine the physical activity of schoolchildren. Satellites transmit data containing information about the location of the satellite and global time. Since all satellites have different positions, the time required for the data to reach the receiver is different, this makes it possible to determine the distance to the satellites and the location of the person. Such technologies will require permission to access the child's devices and will make it possible to determine his activity throughout the day, including after school hours [15].

Radio Frequency Identification (RFID) is a wireless contactless system that uses electromagnetic waves and electromagnetic fields to transmit data from a tag attached to an object to an RFID reader. There are two kinds of tags (tags): active tags, which actively emit radio waves, and passive tags, which can only be read over short distances. Passive tags have virtually no lifespan as they do not require battery power [26].

RFID technology can be presented in the form of a floor covering a gymnasium or an entire school space. Such technology will allow obtaining accurate data on the movement of a child through the school or the number of movements per physical education lesson [22; 27].

Image processing systems are based on the use of optical cameras and computer vision algorithms. The big advantage of such technologies is that there is no need to use markers. Real-time image processing is demanding on computer power, so high-performance components may be required.

The KinectTM sensor was originally developed for a game console and is now widely used in the analysis of sports movements [12; 13]. This system can also be classified as markerless image processing systems, although the principle of operation is slightly different from the optoelectronic systems described earlier. The system projects an infrared laser speckle pattern onto the infrared camera's field of view. Next, the infrared camera detects the speckle pattern and creates a 3D map by measuring the distortion in the reference speckle pattern. Due to its low cost and acceptable accuracy, this device is often used in scientific research. Kinect-based systems capture human postures and gestures [7]. For example, this technology is very relevant for controlling the posture of schoolchildren.

The most difficult in terms of distance and automation is the determination of the non-dynamic component. Currently, the authors are not aware of the massive use of such technologies. However, such technologies already exist in laboratory conditions and will undoubtedly be introduced into practice in the near future. For example, it is theoretically possible to determine the neurodynamic component from the reaction of the pupils to light using an image processing system, or to measure skin conductivity when touching electrodes embedded in door handles.

During the initial implementation, to determine the neurodynamic component of health, it is proposed to use computer games that allow to implicitly determine a simple and complex reaction, conduct a tapping test, and determine the critical frequency of flicker fusion.

The presented technologies are supposed to be combined into a single measuring system. The methodology for studying the health of schoolchildren, therefore, is based on the search for relationships between various components of health, the analysis of cause-and-effect relationships in the dynamics of indicators and the ability to predict further changes in the health of each student.

Conclusion

The article discusses an information-dynamic approach to determining the health of schoolchildren. The peculiarity of the approach lies in its complexity, distance and non-invasiveness, since it is based on non-contact technologies (Table 3). Such an approach will not take the time of schoolchildren for testing, while monitoring their current state of health every minute.

The technologies used in biomechanics, medicine, forensic science, navigation together make it possible to comprehensively assess the psychological, neurodynamic, motor and energy components of schoolchildren's health. The most promising systems for assessing the health of schoolchildren are the following systems: an image processing system (technology for detecting and recognizing faces, technology for recognizing facial expressions and gestures), an optoelectronic measuring system (motion capture technology), an internal thermometry system (acoustothermometry), a navigation system, an electromagnetic measuring system, system of content analysis of Internet traffic, tenso-dynamometric system, as well as neurotechnological system.

All data on the health of a student are brought together in a single database with continuous processing of indicators and automated decision-making. The use of artificial intelligence algorithms and Data Mining tools will allow you to detect hidden relationships between indicators, assess risks and provide personalized recommendations. The data obtained can serve for making decisions on the correction of the educational process, increase in physical activity, and also be used for early diagnosis of serious diseases.

It is planned to start implementing this approach in schools in 7 regions of Central Russia by the end of 2021. Further, it is planned to spread the experience to other schools in all regions.

Currently, a unified information base has already been created for analyzing the data received, a manual has been prepared for setting up its functioning, and applications for registering a database and computer programs have been sent. Training webinars scheduled for October-November 2021.

The technologies presented in the article already exist and are used in various fields. However, it should be recognized that they have not yet received mass distribution, since they are difficult to tinture and expensive. Therefore, the implementation strategy of the proposed concept is a gradual transition from the classical approach based on testing to the information-dynamic approach, which will occur as new technologies of remote control are introduced.

The mechanism of development of the proposed system is associated with further scientific and technical progress and the emergence of new distant technologies that allow you to control health parameters. When such technologies appear, it is planned to integrate them into an existing information system.

Together with the introduction of the proposed approach, it is planned to create an electronic passport of schoolchildren's health with further integration of this module into the domestic electronic educational complex of a student's diary. This will allow you to obtain additional data for analysis on the progress and morbidity of schoolchildren, vaccinations, school workload, passed standards for physical education, and so on.

The practical significance of the introduction of an information-dynamic approach to assessing the health of schoolchildren lies in the improvement of the system for monitoring the health status of schoolchildren and its transition to a new, more modern and technological level.

Preserving and strengthening the health of schoolchildren is the most important condition for improving the demographic situation in Russia. Attention to this problem on the part of managers of various levels is the guarantor of the implementation of the presented concept.

The key factors in the development and implementation of the proposed concept is the further development of the information society in Russia: the progress of information systems, the expansion of computer power for analysis, the widespread distribution and reduction in the cost of technologies.

Financing

The study was carried out under the project "Development and implementation of electronic health passports for monitoring the physical, mental health and physical fitness of participants in the educational process in modern learning conditions", which is implemented with the financial support of the Ministry of Education of the Russian Federation, within the framework of the state assignment (agreement No. 073-03- 2021-017 / 2 dated July 21, 2021).

Acknowledgments

We express our gratitude to the editor of the journal and anonymous reviewers for comments and recommendations when preparing the article.

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