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MONITORING AND CORRECTION OF STUDENTS' FUNCTIONAL STATE BY THE INFORMATION TECHNOLOGY TOOLS

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Приведены результаты анализа информационной технологии (ИТ) мониторинга и коррекции функционального состояния студентов в процессе обучения, созданной на основе разработанных моделей, комплекса критериев классификации составляющих моделей, алгоритмов определения нормализованных оценок, формирования групп и программ психологического сопровождения. ИТ включает три этапа: мониторинг функционального состояния, классификация этого состояния и на основе полученных оценок формирования групп и программ дифференцированного психологического сопровождения и проведение коррекции. На последнем этапе реализуется созданный конструктор психологических тренингов, позволяющий составить дифференцированные программы психологического сопровождения в соответствии с мозаикой состояния функций у исследуемых студентов. Завершается информационная технология повторным тестированием студентов и анализом результатов проведенной психологической коррекции.

Ключевые слова: информационная технология, функциональное состояние студентов, мониторинг и коррекция функционального состояния, программы психологической поддержки.

Надано результати аналізу інформаційної технології (ІТ) моніторингу і корекції функціонального стану студентів у процесі навчання, створеної на основі розроблених моделей, комплексу критеріїв класифікації станів складових моделей, алгоритмів визначення нормалізованих оцінок, формування груп і програм психологічного супроводу. ІТ включає три етапи: моніторинг функціонального стану, класифікація цього стану і на основі отриманих оцінок формування груп та програм диференційованого психологічного супроводу, проведення корекції. На останньому етапі реалізується створений конструктор психологічних тренінгів, що дозволяє скласти диференційовані програми психологічного супроводу відповідно до мозаїки стану різних функцій у досліджуваних студентів. Завершується інформаційна технологія повторним тестуванням студентів і аналізом результатів проведеної психологічної корекції.

Ключові слова: інформаційна технологія, функціональний стан студентів, моніторинг та корекція функціонального стану, програми психологічної підтримки.

INTRODUCTION

The functioning of the educational system is aimed at the professional development of young people, the formation of highly qualified specialists in conjunction with the preservation of their health. The results of numerous studies of students' health testify to its deterioration and the related difficulty of the process of a personality social adaptation. In turn, the inadequacy of the socio-

psychological adaptation to the new conditions often as a positive feedback causes the occurrence of emotional instability and deteriorating health, entails the adaptive adjustment of a personality, resulted in both external and internal conflicts, as well as maladaptive behaviors [1].

For monitoring and correcting changes associated with admission to a higher educational institution planned work of the psychologist in higher education is conducted. Some students have nonspecific physiological and psychological adaptation reactions. Work arrangement with such students combines individual and team work aimed at preventing and correcting the negative effects of stress. The work of a school psychologist includes elements of psychotherapeutic approach for the analysis and overcoming psychological distress of a personality. The effect of external factors through a subjective estimation of their significance by a specific student is taken into account.

One of the most used approaches in the psychological service in education is a socio-psychological approach. The possibility of two kinds of age-related crises is taken into account — the crises of personal formation which may be accompanied by some significant life events (changes in social roles) as well as the crises caused by external causes (sudden changes in living conditions, social relations etc.) [2]. The change of the social status and environment resulting from of admission to the high school at the age of 14–15 may be a factor of the crisis, which can cause a strong impuls to the personal development or disharmony. It is important to monitor student's functional states based on the physical and mental manifestations and reflecting their change in the learning process.

For a full and adequate assessment, monitoring and timely correction of students' functional state (FS) it is necessary to use new information technologies, the preparatory stage of which is the development of a functional state information model. This model displays all the components, their functions and parameters and is the basis for the formation of the complex of testing methods.

The purpose of this work is the analysis of information technology developed for monitoring the functional state of students to form differentiated programs of psychological support in the learning process.

INFORMATION SUPPORT OF INFORMATION TECHNOLOGY

The basis of information technology (IT) is the formed information model of a student’s functional state (IM) including the three main components: intellectual, emotional, and personality-motivational components. In our previous studies intellectual component has been analyzed and the biological functions that provide a cognitive mental processes has been singled out. These functions ensure forming environmental models, establishing links between these models, the ability to save and correcting these models, i.e. active cognitive activity, in solution of actual problems.

The main criterion for changes in the students’ functional state is the decreased or increased effectiveness of the learning tasks, and a leading index of the active psychical functional state is the mental capacity, integrating basic mental functions — perception, attention, memory, and thinking. Therefore, the intellectual component is described by these specified system functions. The

characteristics of the functions are obtained by using known psycho diagnostic tests [3, 4].

We study the speed characteristics of perception arising from the action of simple visual and auditory signals, and the system characteristics of a higher level of perception — perception of time and space. To determine these parameters the registration time perception of simple sensorimotor reaction, modified test of Franz Halberg "individual minute" [5], measuring of the segment with predetermined length and its comparison with the real standard are used.

The main attention estimation parametres are the volume, concentration, stability, refocusing, which are determined by proofreading test.

The need to determine the current state of the memory function allows using the characteristics of short-term memory — the volume of stored and replicated information.

Depending on the involved elements and operations, it is proposed to determine thinking function by the atitudes of the abstract, associative, logical, operational, and spatial thinking.

The emotional component consists of three elements: the actual psychic experiences (internal emotional component), the manifestation of emotions (external emotional component) and changes in the functioning of the internal organs (component of physiological response). In this study we pay attention to two elements — impressive (inner feelings) and expressive (manifestation of emotions) functions. According to our classification each of these functions is represented by six characteristics in accordance with the basic feelings groups: safety, affection, self-esteem, activation, pleasure and feelings of affectation. These characteristics are determined by a designed questionnaire, included in an automated system [6]. As the system ability to generate internal and external manifestations of emotions the selected index of general emotional intensity is singled out. The difference between these two functions is represented by an emotional disbalance.

Another indicator of the emotional sphere imbalance is anxiety: resonal anxiety as a stable feature, reactive anxiety as an actual state [7]. We should take into account that the optimal level of anxiety is a natural and obligatory feature of an active person, but increased rates may cause stress, anxiety, disorders of attention and fine motor coordination.

The personality-motivational component combines functions of interpersonal relationships: conformity and nonconformity. These functions are marked by us based on T. Leary concept of interpersonal relationships [8] and L.N. Sobchik individually-typological approach [9].

The function of nonconformity is characterised by four trends (octants), to each of which is manifested by a certain style of interpersonal behavior: imperious-leading, independent-dominating, straight forward-aggressive, distrustful-skeptical. Octants of konformity function are: humble-shy, dependent-docile, cooperative-conventional, responsible-generous. When creating an information model two forms of “I-concept” are considered: ”I-actual” — a self-image that most accurately characterizes the personality at the moment, and “I-ideal” — representation of oneself in accordance with the ideals and desires. Correlation between “I- actual” and “I-ideal” underlies personality adaptation mechanisms,

differences between these forms indicate the direction of the changes of functions in the personality-motivational component. Features of highlighted functions are determined by the test T. Leary adapted L.N. Sobchik as “Test of interpersonal relations” [9].

Information model is a hierarchical system: level I — integral (generalized) functional state assessment, each component (level II) is described by the corresponding system functions (level III) whose state is determined by one or more absolute and/or relative characteristics (level IV). The formed automated complex methods for quantitative characteristics of level IV are based on the developed information model.

Algorithm to Determine the Relative Formalized Assessments of the FS

The algorithm is based on a number of methodological approaches, including preprocessing data array, the normalizating indicators, and developing integral estimates [10–12]. Here are the stages of the proposed algorithm enlarged.

Stage I. Formation and qualitative analysis of the generalized initial dataset. In accordance with the information model a single table on entire dataset has been developed. Culling numerical values is carried out — excluding data that are artifacts or those remaining unchanged with the change of object state (from one class to another).

For further comparative analysis it is necessary to carry out the procedure of normalization and integration assessments formation.

Stage II . Normalization of indexes.

At the beginning of this stage the basic value is selected. This value can be obtained as follows:

— Calculated on the base of the original data set (average, maximum and minimum values, the lower and upper limits of the confidence interval);

— Defined as the norm for this index (from directories based on the age, sex and other characteristics);

— Adopted as a kind of "ideal" value of this index;

— Defined as the range of values that meets the criteria limits or range of primary data changes in the array.

The latest approach has been used for developing this information technology.

Using the selected reference/basic value, relative index defined as the ratio of the current value (in units) to the selected basic constant value (in units). The result is a dimensionless relative value.

To determine the range of variation index of 0 to 1 normalization procedure is performed using linear and nonlinear functions.

For linear normalization the following formulae are used:

$$D = \frac{x_{\max} - x_i}{x_{\max} - x_{\min}} \quad \text{for decreasing the normalizating function;} \qquad (1)$$

$$D = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \qquad \text{for increasing the normalizating function} \qquad (2)$$

where x_{max}, x_{min}, x_i are the maximum, minimum and current index undergoing normalization.

The normalized value of the index equal to 1 represents the best state of investigated characteristics. Increasing the value of the index at a decreasing normalization function indicates deterioration of the analyzed characteristics, and that with increasing function — an improvement of the state, and vice versa.

In nonlinear data normalization exponential (decreasing or increasing), arc tangent functions and distribution (normal, Weibull, Rayleigh, and others) are used.

To solve the tasks of our research it is important to single out the optimum values in normal range of investigated index, then the definition of normalized valuations must be done including the selected range: $x_{-op} < x_i < x_{+op}$ where x_{+op} and x_{-op} are boundary values range of x_{op} + 10%. So the normalized score is calculated:

$$D = \begin{cases} \dfrac{x_i - x_{+op}}{\left| x_{+op} - x_{\max} \right|} & x_i > x_{+op} \\ \dfrac{x_i - x_{-op}}{\left| x_{-op} - x_{\min} \right|} & x_i < x_{-op} \\ 1 & x_{+op} < x_i < x_{+op} \end{cases} \qquad (3)$$

The values $x_{\max}$, $x_{\min}$ are determined from the conditions of the test task or of the confidence interval limits: $x_{\min}, x_{\max} = \bar{x} \pm t_{\alpha,n}\sigma$ where $\bar{x}$ is the arithmetic mean; σ is standard deviation; t is quantile of the Student distribution; α is the level of significance; n is the number of freedom degrees.

Stage III. Forming integral assessments.

Mostly in medical and biological research calculating the arithmetic mean or the geometric mean of all received estimates is carried out to combine the received normalized indicators for integral evaluation. Each normalized index is assigned weight (using the peer review or largest variability indicators, etc.).

It is possible to calculate integral evaluation using a formula with the additional probabilities of weight of each indicator or calculation of additional probabilities averaged over the arithmetic mean or geometric mean.

Thus, in the first step normalized evaluation indices were calculated (level IV of the information model). Integral estimates of the following levels were calculated as a weighted average, combining the estimates of lower level: integrated assessment functions (level III) combines normalized index assessment (level IV), integral components assessment (level II) assesses the functions and integral (generalized) evaluation of the functional state (level I) combines integrated assessment of intellectual, emotional, and personality-motivational components.

The application integral indicators for the analysis of the functional state and its components allowed assigning a specific state of these systems quantitative assessment, to move from verbal to quantitative measures.

MONITORING THE STUDENTS' FUNCTIONAL STATE

The study of the developed information model was conducted with the students of Vinnitsa Medical College named after academician D.K. Zabolotniy, two groups with different learning load were compared: group I is students of medical and biological lyceum and group II is students specializing in "Pharmacy".

Students' workload of medical and biological lyceum classes corresponds to 10–11 secondary school with advanced study of chemistry and biology, they choose speciality after two years of study. Pharmacy students (group II) have chosen their career before admission to college, they have three years training and high learning load.

Testing was conducted four times a year, at the beginning and the end of each two terms. The total volume of research is 218 people.

The experimental groups were homogeneous in terms of age: group I — 14–17 years old, group II — 14–18 years old (including three years of study). Results of the study indicate that the academic load affects all personality structure.

Analysis of the average group characteristics revealed differences in dynamics of the students' functional state in the two compared groups during the year. The first test (the beginning of the first semester) showed that the functional state of pharmacy students (group II) was worse than the students of lyceum (group I) in all components: the speed of simple sensorimotor reaction was lower, indicators of memory, thinking, emotional intensity and levels of emotional disbalance were lower, personal and reactive anxiety was elevated, the difference between the "I-actual" and "I-ideal" was increased, information profiles of conformity and nonconformity functions were different.

In the first terms students adapt to the new life rhythm and learning conditions/environments, and foundations of relationships with peers and teachers are formed. These processes are reflected in the functional state, their common feature is the change of attributes which indicate stress: heart rate was improved, rate of simple sensorimotor reaction, attention and memory indexes were increased. However, different workload entails various changes in the functional state of the students of the two analyzed groups. In particular this applies to emotional and personal-motivational components: emotional intensity of the students of group II was decreased, indexes of emotions of pleasure and activation were lowered, while indexes of affect feelings were increased, emotional disbalance has come down.

It is especially important to identify changes in the individual functional state of students. As these changes were present in all components of functional state in varying degrees the problems of the monitoring the state of each student and additional psychological support differentiated according to the results of this monitoring were arose. Preliminary studies of the dynamics of information model (functions, components and integral assessment of the students' functional state during the school year allowed to reveal temporal milestones, to point out

reduction of these indicators and to identify periods for additional psychological support.

The orientation of programs of differentiated psychological support was determined with regard to the specificity of intellectual, emotional, and personality-motivational components of the functional state. The need for specific training program was determined by the deterioration indexes of the functional state. Algorithm for the formation of groups of students, who were recommended to participate in the classes of specialized psychological support, was developed.

DATAWARE OF STUDENTS' FUNCTIONAL STATE CORRECTION IN THE LEARNING PROCESS

The task of automating the formation of differentiated psychological support groups is solved by using the developed algorithm, which allows us to analyze the students' functional state based on a hierarchical information model. The analysis begins with an examination of the highest-level models — the level of integral assessment, and further the state of intellectual, emotional, and personality-motivational components and their functions are revealed step by step.

From the values of the integral assessment of the functional states (DF_i) three classes of FS were singled out:

— Class F_1 — good functional state at $1 \geq DF_i > 0{,}66$;

— Class F_2 — satisfactory functional state at $0{,}66 \geq DF_i > 0{,}33$;

— Class F_3 — unsatisfactory functional state at $DF_i \leq 0{,}33$.

In the first step of the algorithm each student was assigned according to the test results to one of these three classes of general functional state (FS is the highest level of information models).

Students, the general condition of which corresponds to the class F1 (good functional state), do not require additional psychological support and, consequently, are not included in further consideration.

In the second step of the algorithm calculation and analysis of assessments of intellectual (DI_i), emotional (DE_i) and personal-motivational (DL_i) components are carried out taking into account the integrated assessment of the functional state (DF_i). For dividing classes of these components state the system of criteria was formed, in tab. 1 criteria for determining the state of classes of intellectual component are shown.

In the second step three groups, singled out of the basis of deterioration of intellectual (F_2I_1, F_2I_2, F_2I_3, F_3I_1, F_3I_2, F_3I_3), emotional (F_2I_1, F_2I_2, F_2I_3, F_3I_1, F_3I_2, F_3I_3) and personal-motivational (F_2L_1, F_2L_2, F_2L_3, F_3L_1, F_3L_2, F_3L_3) components with varying degrees of change in this state were revealed.

Good state of particular components, e.g. the intellectual component (I_1), at satisfactory (F_2) or unsatisfactory (F_3) general functional state suggests that this deterioration of general functional state was due to negative changes in emotional and/or motivational areas. Therefore, students whose state is determined in classes F_2I_1, F_3I_1, F_2E_1, F_3E_1, F_2L_1 and F_3L_1, will be assigned to groups focused on correction of deterioration in complementary components (in this case emotional and/or motivational) and their functions.

In the third step of the algorithm analysis of the next hierarchy level — analysis of the functions which provide the analyzed components — is carried out. To determine the state of particular functions the division into three classes is done based on the general principle of determining the limits of these classes: good ($1 \geq X_i > 0{,}66$ where X_i is the normalized value of the analyzed function), satisfactory ($0{,}66 \geq X_i > 0{,}33$) and unsatisfactory ($X_i \leq 0{,}33$) functional state.

Table 1

Criteria for determining the classes on normalized estimates of the state intellectual component

Class indication	Class descripyion	Class criteria
Intellectual component (IC)		
F_2I_1	IC good state IC, satisfactory general FS	$1 \geq DI_i > 0{,}66$ $0{,}66 \geq DF_i > 0{,}33$
F_2I_2	IP satisfactory state, satisfactory general FS	$0{,}66 \geq DI_i > 0{,}33$ $0{,}66 \geq DF_i > 0{,}33$
F_2I_3	IC unsatisfactory state, satisfactory general FS	$DI_i \leq 0{,}33$ $0{,}66 \geq DF_i > 0{,}33$
F_3I_1	IP good state, unsatisfactory general FS	$1 \geq DI_i > 0{,}66$ $DF_i \leq 0{,}33$
F_3I_2	IP satisfactory state, unsatisfactory general FS	$0{,}66 \geq DI_i > 0{,}33$ $DF_i \leq 0{,}33$
F_3I_3	IP unsatisfactory state, unsatisfactory general FS	$DI_i \leq 0{,}33$ $DF_i \leq 0{,}33$

For example, in the case of reducing intellectual indexes the problem of identification specific functions responsible for this deterioration is solved. And the psychologist knows that this particular student needs training of functions of attention, memory and/or thinking.

As a result of applying this algorithm three aggregated groups of additional psychological support are formed with a focus on intellectual, emotional and personality-motivational components. And definition of functions the state of which has been defined as unsatisfactory or satisfactory was done for each student.

SET OF DIFFERENTIATED PROGRAMS FOR PSYCHOLOGICAL SUPPORT

Application of the algorithm, which allows classifying the FS of a particular students on monitoring results showed a variety of state combinations of different components and their functions in the students. To take into account these functional state mosaics in the preparation of differentiated programs of psychological support, we used the designer's approach. The elements of the developed set were trainings aimed at the intellectual, emotional, motivational aspects of psychical activities, using proven methods.

Functional training included the development of memory, basis of eidetic and efficient memorization, the development of attention, thinking, and creativity. Emotional state training control is aimed at developing the ability to determine the level of stress and causes of negative emotions, to exercise the self-analysis of behaviors in problematic situations, to acquaint with the way the negative emotions transformation, to develop patterns of behavior in intricate situations, to apply the technique of self-regulation, etc.

It is very important to carry out the conflict control training, giving information of the types and causes of conflict, types of conflicting personalities

and behaviors in conflict, the technology depreciation and conflict regulation, forming the ability to criticize constructively and to perceive criticism. The training of partner relations allows to achieve enhancement of the skills in communication, self-knowledge, the development of verbal and nonverbal manners of communication, constructive ways of interaction. The training of assertiveness promotes the development of skills of confident nonaggressive behavior, a clearer perception of their rights and opportunities with regard to the rights and aims of other people.

The perception of time has a stable relationship with other mental functions. On the one hand, all the senses (sight, hearing, and tactual sensation) give information about time. On the other hand, all the psychological functions unfold within time limits. Real perception of time is reflected subjectively in the sensations duration of all mental experiences/feelings [9]. So we involved a special group of time control training, aimed at developing the ability to plan and prioritize, set goals and effectively organize the fulfillment of work assignments, understanding the principles of the organization of effective self-control, methods and techniques of time management.

The elements of psychological training set are organized into three basic blocks of training: "Line of Intellect" aimed at correction of situational reducing the implementation of cognitive functions; "Line of Heart" determining the causes and conditions for reducing emotional imbalance, formation the skill of adequately feelings manifestation, identifying internal emotional resources to prevent chronic fatigue and emotional burnout; "Line of Life" recommended by the low assessments of the personal-motivational component, availability of character accentuation or potential internal conflict.

Using the developed psychological training set allowed us to form effecting by a program for each particular group of additional psychological support, taking into account the need to correct the state of certain functions of the intellectual, emotional or personality-motivational components. If necessary, in parallel with the team work individual counseling was carried out.

Information Technology of Monitoring and Correction of Students' Functional State

Based on the developed models, a set of criteria classification, algorithms for determining the normalized estimates and forming groups of psychological support the information technology for monitoring and correction of students' functional state in the learning process was developed. Information technology includes three major stages: monitoring the functional state, the classification of this state and on the basis of obtaned estimates formation of differentiated programs of psychological support and its correcting (Fig. 1).

Monitoring the functional state (stage I). At this stage the testing of students with the help of the developed automated system, which was based on the hierarchical structure of the functional state information model.

Indexes of intellectual and personal-motivational components are determined using proven methods of psycho-diagnostics, the characteristics of the emotional component are defined using our proposed classification of emotions, approach of

measuring expressive and impressive functions, the emotional saturation and emotional disbalance, as well as test method to determine them. According to the test results normalized assessments of all levels of the hierarchical information model were generated.

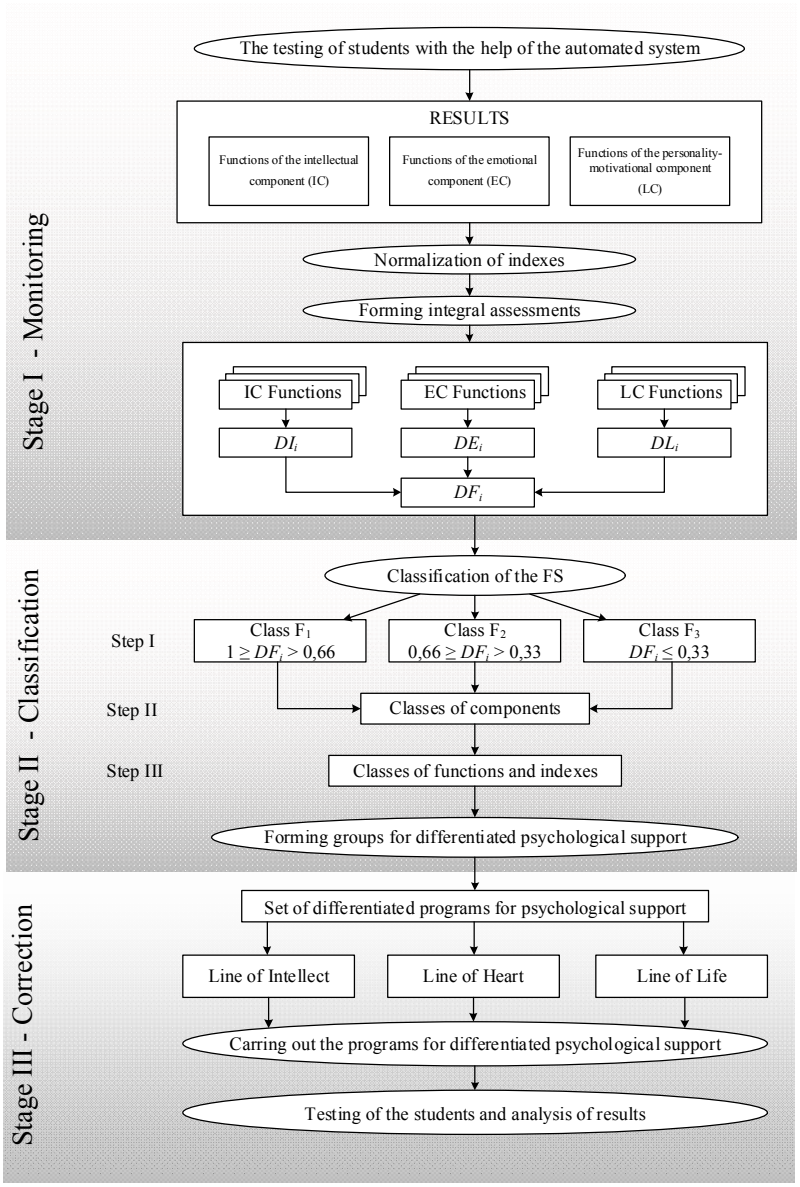

Fig. 1. Information technology of monitoring and correction of students' functional state

Classification of the functional state (stage II). Calculated integral FS assessments are input for classification the state of each student using the proposed set of criteria for classes of functional state.

The developed algorithm of formation the groups of additional mental accompaniment uses the results of the functional state classification, quantifies and verbal description of this state that allows us to include a particular individual to the appropriate group to participate in psychological training.

Formation of differentiated psychological support programs and carrying out the correction of students' functional state (stage III). At this stage, the created psychological training set is realized, which allows to make a differentiated program of psychological support in accordance with a combinations variety of different components and their functions states obtained for the studied students.

Work with students under formed programs lasts throughout the term, it is followed by testing of the participants of these programs and analysis of their functional state.

Application of the information technology in each term allows to correct and further maintain of the student's functional state at a good level, which increases the efficiency of the learning process.

CONCLUSIONS

Monitoring functional status using the developed information technology can detect the need for additional psychological support. The results show a mosaic combination of psychological functions states that require correction forming the basis of the formation of differentiated programs of the psychologist's additional work. Evaluation of the results of the students' functional state correction indicates an improvement in functional reserves for the improve of the efficiency of the educational process.

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