

EXPERIMENTAL ESTIMATION OF ERGONOMIC PARAMETERS OF THE COMPUTER TRAINING PROGRAMS ON ELECTROTECHNICAL DISCIPLINES

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The abstract: The present research offers the technique of the experimental estimation of the ergonomic parameters of the computer training programs, created on the basis of the method of theoretical images are submitted.

Key words: the computer training programs, ergonomic parameters, method of theoretical images

Introduction

Computerization as well as the information process built on it are being widely implemented in all spheres of human life, including such an important sphere of social activity as education. New information technologies and computer-based facilities being the nucleus of the information process of education. Nowadays a computer classroom in the educational institution has become the same necessary and habitual attribute, as library. New means of training: all kinds of computer training programs (CTP), including electronic textbooks (ET) are developed.

The learning efficiency is influenced by various factors, among which comfortable conditions for work with the computer program are great importance. The analysis of this aspect of interaction of the person and computer will be carried out within the framework of ergonomics – the science that studies in complex the law of interaction of the person and engineering during this or that activity with the purpose of development of the requirements for increasing the efficiency of this activity. In the present research the task was to estimate the ergonomic parameters of a number of computer educational programs on Electrical Engineering.

The basic part

The electronic textbook, as a special case of the man - machine system (MMS), is characterized by system-technical and ergonomic properties. According to [Зараковский и др., 1993, с.27], system-technical properties are those that cause the adaptation MMS to performing its appropriate functions (efficiency, reliability, cost, etc.). Ergonomic property - characteristic of MMS and its elements, which are defined by biomechanical, physiological and psychological possibilities of human activities.

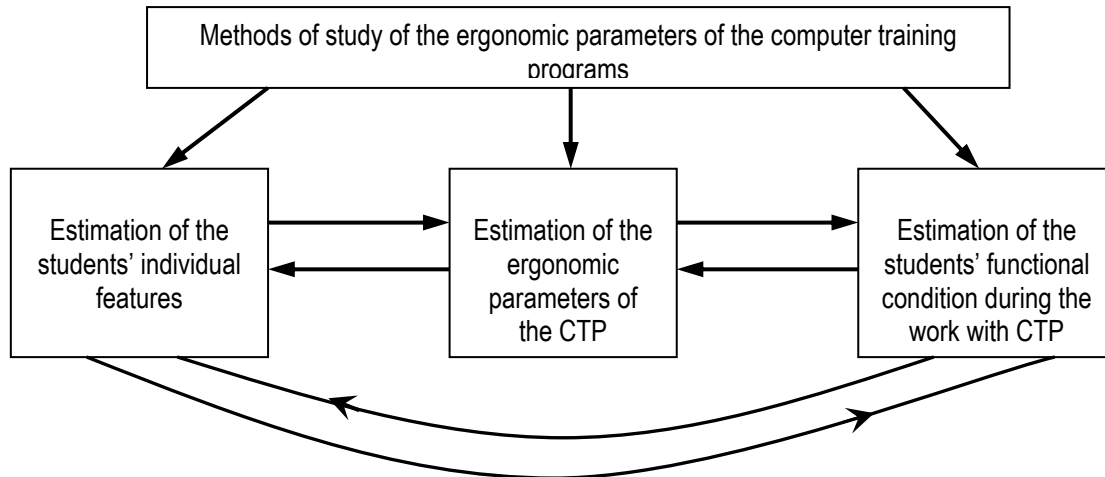
Already at the first stages of the development of computer facilities the problem of interaction of the person and computer has become a subject of research in engineering psychology, ergonomics, psychology of labor. Various aspects of an operator's work with the use of a computer were originally examined in Automatic Management System. The most attention was paid to optimization of hardware component of the human-machine interface (HMI). Now, because of the constant perfection of computer engineering the ergonomics attention was switched to software components of HMI. Recently some researches have been ergonomic carried out which dealt with ergonomic designing of interaction of the man and computer in the system of educational: preschool, secondary, university; the questions of maintenance of optimum work conditions being mostly examined: such correct mode, the microclimatic conditions, the light exposure, the correct pose during with work, the organization of the workplace. But the questions of the ergonomic of optimization of properties of CTP are paid less attention to. The recommendations on organizing the procedure of dialogue, the adaptations of the program to students' individual features, on color and spatial design of the information on the display are often of generalized character. There are not any works investigating the ergonomic properties of CTP of a narrow purpose and having their own specific character, for example, for teaching general-engineering disciplines (GED). Thus, the question of the estimation of quality of educational software is extremely urgent.

One of central problems of ergonomics is the study of functional condition of the users arising during this or that activity, and the development of adequate methods of their estimation and correction. Functional condition (FC) of the person - complex of the characteristics of those functions and qualities of the person, which directly or indirectly determine performance of working operations [Введение в эргономику, 1974, с.94].

Traditionally researched types of FC are exhaustion, tension, stress. As the phenomena of physical and mental exhaustion, as well as the way of their description can depend in great degree on the examinees, personal peculiarities and aims, it is also advisable to get his personal profile, especially concerning his

stability and introversion / extraversion. The factors, causing the increased motivation of the user also require deep study.

Taking the above-stated facts into account, as well as the specificity of teaching GED with the use of information technologies and using the data of the analysis of the scientific literature devoted to the ergonomic criteria of efficiency of activity and the questions of psychological testing, Yakovets D.A. has developed a technique of an experimental research of ergonomic parameters of computer training programs (picture 1.).



Picture 1

Nowadays we have a situation when the greatest number of CTP under development belongs to the branches of humanitarian disciplines and natural sciences disciplines for the school system of education. The quota of CTP on general engineering disciplines (electrical engineering, heat engineering, hydraulics, theoretical mechanics, etc.) and special technical disciplines (according to the profile of the graduating faculties) is insignificant. One of the reasons that slows down the development of CTP on technical disciplines for system of secondary and higher education is the lack of theoretical bases of ergonomic designing of the similar programs.

The present research offer the method, of an experimental estimation of the ergonomic parameters of CTP enables the comparative analysis of the existing CTP. This technique has been applied for the estimation of the several computer training programs on electrical engineering. The research were carried out on «The Three-phase circuits» (TZ) program, created on Electrical Engineers Faculty of Astrakhan State Technical University (ASTU), as well as «The Theory of electrical circuits » (TEC) program, developed in Siberian State Academy of Telecommunication and Computer Science [Бакалов и др., 1998].

We consider that the TEC computer program represents the most widespread type of modelling program in the branch of engineering disciplines. The software for mathematical and imitating modeling allows expanding the borders of experimental and theoretical researches, to supplement a physical experiment. During the work with the TEC program the student is given the possibility to choose the necessary parameters of the electric circuit, the TEC program demonstrates the change which occurs in the work mode of the circuit. The drawback of the similar programs is the lack of feedback and of active educational activity of the students. The student acts in a role of the observer. On the finishing work with the TEC program the student isn't given any mark for the lesson.

The TZ program is an electronic textbook. According to [Зайнутдинова, 1999¹, с.35]: " The Electronic textbook (ET) is an educational program system of a complex purpose, ensuring the continuity and completeness of the didactic cycle of the teaching process, which gives the theoretical material, ensuring the drilling activity and the control of the level of knowledge, as well as the information retrieval activity, mathematical and imitating modeling with the computer visualization and service functions on the condition of realization of an interactive feedback".

The program TZ is designed on the basis of the method of theoretical images [Зайнутдинова, 1999²]. The educational material of the GED is know for its high level of abstraction and therefore is perceived and acquired by the students with difficulty. The offered method of theoretical images ensures the increase of availability of the form of an abstract educational material.

The scientific knowledge is in the overwhelming majority of passed on in verbal form as theories, laws, concepts and is accompanied by some symbolical explanations, for example, mathematical formulas, it enables to speak about the verbalized form of scientific knowledge. It is known from psychology that for understanding and mastering the educational material well, the semantics of the text should be represented in the form of visual images. On the basis of the above-stated facts, the author of the present work introduces the following definition: "The Theoretical image is a visual-figurative representation of the semantics of the verbal forms of scientific knowledge (concepts, laws, theories)" [Зайнутдинова, 1997, с.164].

One of interest, but poorly developed problems is the problem of passing on the image from one person to other during dialogue [Ломов, 1991, с.69]. It is that problem that comes to the foreground in computer training systems. The theoretical image that has been formed in experienced teacher's consciousness for many years, can not be directly handed down to, the student. During the application of the traditional technology an image passes on to other person on the thinking-in-words level. The application of new information technologies principally new possibilities appear, which enable to pass on the visual - figurative concepts from the teacher to the student. The necessity of a verbal description is reduced. The theoretical image being property of the experienced teacher can be passed down to the student with the least losses and distortions through a didactic program system. But there is a necessity for the development of new technologies or strategy of such transmission. On the basis of the psychological and pedagogical theories of training the present research gives recommendations for designing theoretical images for CTP [Зайнутдинова, 1999¹, С.144-145].

The method of theoretical images is capable to some extent to affect all the components of the student's learning process, but the most significant changes take place during the perception, understanding, memorizing and revision of the educational material. Besides the method is supposed to improve the emotional attitude to the process of learning and to reduce the necessity for volitional efforts on the part of the student. While using the method of theoretical images the educational information is given not only as texts and formulas, but also in a visual - figurative form. Both the verbalized left-hemispheric and the visual right - hemispheric information are perceived simultaneously. The processing of the right -hemispheric information is carried out at high speed, in complex. There is a sort of a complex (synergism) effect of interaction of the left - and right -hemispheric mechanisms of our thinking. At the achieved level of the quality of both hardware and software the visuality and vividness of the information can attract the user's attention to such extent that the necessity for a volitional regulation of the process of perception and understanding is reduced considerable. The method of theoretical images has high potential possibilities of presentation of the educational material with the support on the interrelation and interaction of conceptual, figurative and effective components of thinking, what is of immense importance for the creation of the CTP for general-engineering disciplines.

The high pedagogical efficiency CTP, developed with application of the method of theoretical images, was confirmed by research [Зайнутдинова, 1999²]. The aim of the present work is comparative experimental estimation of the ergonomic parameters of a number of CTP on Electrical Engineering: the TEC modeling program and the TZ program, the latter being created with the application of the method of theoretical images. The experimental research was carried out among 85 ASTU full-time students of the second year. It was participated by the students of the following specialties:

- « The Automated systems of processing of the information and management (AS) - 220200 », 31 persons;
- « Automation of technological processes and enterprises (AP) 210200 », 22 persons;
- « Networks of communication and commutation system (AC) 200900 », 32 persons.

The research was carried out in two stages. At the first stage the individual peculiarities of the personalities of the students who take part in the experiment were being estimated. At the second stage the ergonomic parameters of the computer educational programs and student functional state during the work with these programs were being estimated.

The first stage of research

The estimation of the students individual personal peculiarities was carried out once at the specially arranged time (at the lecture).

For the estimation of the student's individual features (IF) it is necessary to fulfil some requirements:

1. The techniques of the estimation of the student's IF should be reliable and valid.

2. The techniques of the estimation of the student's IF should be convenient for a group testing. It is necessary to ensure the equal conditions of testing. The procedure of measuring, processing and interpretation of the investigated parameters should be limited in time.
3. The time required for carrying out the tests is to be taken into consideration (the IF-estimation is to be carried out during one lecture).

The first stage of research included:

1. The definition of the student's professional propensities.
2. The definition of the level of logical ability of thinking.
3. The definition of the basic properties of the nervous system:
 - The steadiness of the nervous system (the balance of nervous processes, expresses the correlation between the processes of excitement and inhibition in the cells of the cortex);
 - Mobility of nervous system (ability to react quickly to changes in the environment);
 - The force of nervous system (reflects a limit of efficiency of the cell of the cortex - their capacity to endure either very strong or very long-termed though not strong excitement, without coming to the state of inhibition).

The definition of the student's professional propensities. As the authors see for the estimation of the level of the student's interest in the study of GED it is very important to reveal their professional propensities. Presence or absence of a positive motivation during the work with a computer program is an important factor that influences to a learning efficiency, the perception of the properties of CTP, the creation of the state of functional comfort or functional discomfort. According to [Чайнова, 1985] The functional comfort is the optimum functional condition of the working person, during which the correlation between the means and conditions of work is achieved. In this case the person develops a positive attitude to his activity, which ensures the adequate activation of his psycho-physiological processes, postpones the development of exhaustion, promotes long and high capacity for work without detriment to health.

On the basis of the analysis of the literature on psychological testing and concordance with the above-state requirements, for the definition of the student's professional propensities differential - diagnostic questionnaire by E.A. Klimov [Горбатов, 1998].

The definition of the level of logical ability of thinking. As it is noted in the work [Зайнутдинова, 1999², с.95], while teaching GED, where also electrical engineer belongs, the student must form in his memory rather great number (a bank) of theoretical concepts, taking into account their interrelations. Besides the system of the scientific notions of GED are characterized by a high level of hierarchism and abstraction and a high degree logical interrelation of its components. Therefore, the authors maintain, that the level of the development of the logical ability of thinking is an important factor that affects the efficiency of the students work with the date of CTP. The level of the development of the logical ability of thinking was investigated with the help of the increasing difficulty test (Roven's technique) [Столяренко, 2000, с.111]. The given test corresponds to the above mentioned requirements.

The definition of the basic properties of the nervous system of the students participating in experiment, is of great importance for the given research. According to [Словарь ..., 1998, с.600], the property of nervous system are the steady features of nervous system, that influence, when all the other conditions are equal, the person's individual psychological peculiarities. The whole set of the nervous system, forming a certain type of the nervous system, makes a physiological basis of the individual originality of the person's activity, directly influences a functional condition (exhaustion, stress, functional comfort, productive or unproductive tension, etc.) during various activities. Laboratory techniques for the diagnostics of the basic properties of nervous system require special conditions of realization and equipment. They are rather labor-consuming. Therefore in this research for the definition of steadiness and mobility of the nervous system the authors used the questionnaire Y. Strelyau [Столяренко, 2000, с.180], and a Tepping-test [Столяренко, 2000, с.187] for the definition of the force of nervous system.

The results of the first stage of an experimental research (the estimation of individual features of the students' personality) have shown:

1. Among the students of the three specialties (AS - 83 %, AP - 86 %, AC - 63 %) the great majority displayed propensity for trades, whose labor objects are both / either technical and / or sign information, i.e. for the activity that presuppose the usage of various machines, materials, other products of a civilization and / or based upon the preferences to processing figures, letters, codes, other symbols.

Thus, it was found out, that for the quota of the students participating in the experiment, the choice of trade is basically adequate to the person's propensities. Hence, it is possible to assume a positive motivation of the students and their interest in mastering material in the Electrical Engineering.

2. The majority of students, participating in the experiment, have a high or middle level logical ability of thinking: in the stream AP - 83 % from the general number of the students of this specialty, AC - 97 %, AS - 95%. Therefore, the students participating in the experiment have a sufficient level of the logical ability of thinking for perception and mastering of the educational material in GED.

3. The students of all the three specialties have weak or middle-weak nervous system. The advantage of the weak nervous system over a stronger one is in its capability to react to stimuli of lower intensity. The weak nervous system is more delicately organized, is more sensitive. Hence, the influence of various properties of CTP on the students' functional condition during the work with the given programs will be displayed to a great extent..

The second stage of the research

The estimation of the ergonomic parameters of the computer training programs and the students' functional state during the work with CTP on Electrical Engineering was carried out in practical lesson in a display classes during few lessons.

While operating a computer the significant part of the information is perceived by the person through the visual analyzer. The increase of quality of the displayed visual information can be performed in two directions: the optimization of the light mode (the brightness, the light exposure in the room, the contrast of elements on the screen) and optimization of human-machine dialogue. It is necessary to note, that the continuous perfection of computer engineering leads to the reduction of the urgency of an estimation and control of hardware parameters of display. Therefore ergonomists' attention is concentrated today, mainly, on the area of the software of the processes of the information display. The present research will be carried out within the framework of the given direction.

On the basis of the analysis of the scientific literature, devoted questions of the ergonomic designing of software of various purposes and a long-termed practice of using electronic textbooks in educational process in ASTU it was suggested in the present work that the following ergonomic parameters should be introduced for the estimation of the quality of the training programs:

1. The used color scale: excessively bright; normal; insufficiently bright.
2. The convenience of reading the information: small print, normal; excessively large.
3. The spatial arrangement of elements of the information on the screen: inconvenient; rather convenient; convenient.
4. Dynamic presentation of the information (moving objects on the screen): promotes a better understanding of the educational information; does not improve the perception of the educational information; irritates.
5. The degree of clearness of the sequence of actions during the work with the program: the sequence of actions clear; sometimes there are difficulties in understanding the sequence of actions; the sequence of actions not clear.

The authors used the method of filling a questionnaire. The students estimated a particular computer training program according to the given parameters at the end of the lessons in this program.

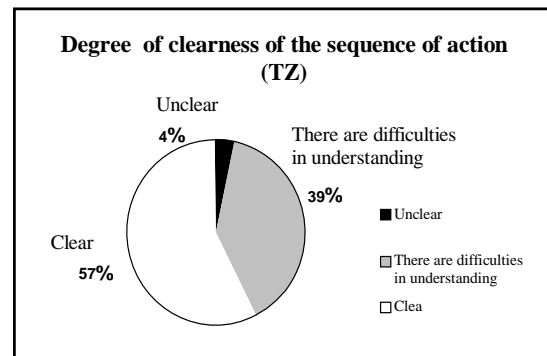
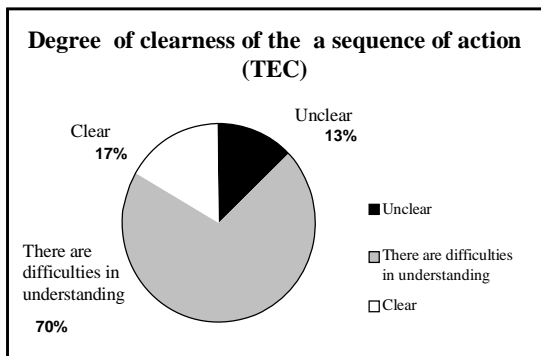
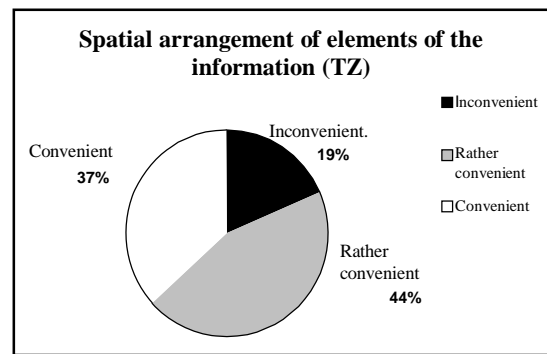
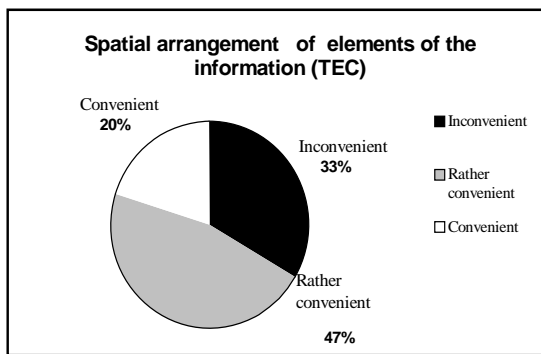
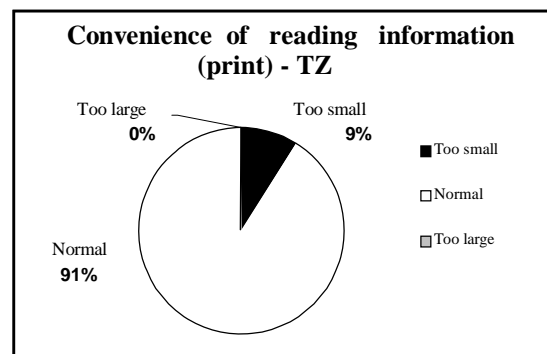
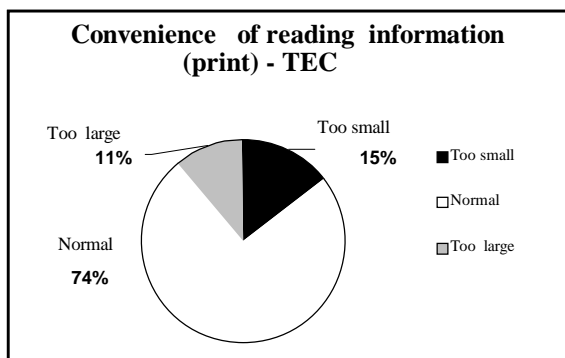
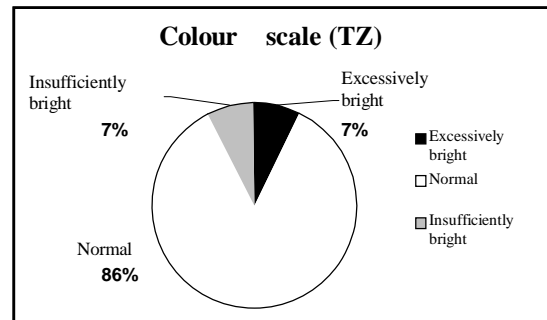
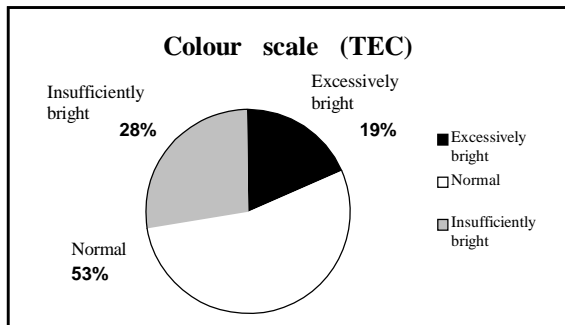
The results of an experimental research of the ergonomic properties of TZ and TEC are show in pict.2. The diagrams illustrate a great advantage of TZ over TEC in all parameters: a spatial arrangement of the elements of the information, the degree of clearness of the sequence of actions, a color scale, the convenience of reading of the information (a print).

While estimating the students' functional state (FS) during the work with CTP it was necessary to meet some requirements:

1. The estimation techniques should be reliable and valid.
2. The estimation techniques FS should be convenient for a group testing.
3. The FS estimation should not interrupt the plan of the educational process. The time spent on the FS estimation should not exceed 10 minutes (5 minutes at the beginning of the lessons and 5 minutes at the end).

For an estimation of the functional state (FS) ergonomics uses two type of methods: physiological and psychological [Эргономика, 1988]. From physiological methods of the estimation FS the given research uses the measurement of pressure and pulse.

Picture 2. THE ESTIMATION OF THE ERGONOMIC PARAMETERS OF THE TEC AND TZ COMPUTER PROGRAMS



These physiological parameters were measured selectively of some students at the beginning and at the end of the lesson. The students for the control were chosen on the basis of the results of the tests on the properties of nervous system. Students with the weakest and the least steady nervous system were chosen as well as with the strongest and the steadiest nervous systems.

For diagnostics of the FS changes psychological tests for the volume of short-term visual memory (a test for storing of numbers) and also volume of distribution and switching of the attention («A Numerical square») test were used [Рабочая книга ..., 1996, с.172-174].

The results of the FS estimation with the usage psychometric techniques have shown:

The reduction of the volume of the short-term memory during work with TZ was registered of almost half of students, whereas during the work with TEC the reduction of the volume of short-term memory was observed of a smaller number of students (AS - 19 %, AP + AC - 28 %).

The reduction of the volume of distribution and switching of the attention during the work with TZ is larger that with TEC (TZ -43 %, TEC- 30 % accordingly).

It is possible to explain the received results by a greater intensity of the learning activity of the students during the work with the TZ program (the students do the calculation of electrical circuits, draw vector diagrams and get a mark for each task). The work with the modeling program TEC is reduced only to observance of diagrams and vector diagrams, a mark for the lesson is not given.

For a subjective estimation of their functional state at the end of the lesson the students were offered a test, prepared on the basis of the test of the differentiated self-estimation (SAM) [Столяренко, с.367]. The parameters were chosen according to the scales «State of health», «Activity», «Mood» that has the clearest and the most precise formulation. The examinees were asked to link their sensations with a number of properties; the definition of each of them should be as curt as possible. The following parameters were estimated:

1. The self-estimation of state of one's health (feels well; badly; it's difficult to answer).
2. Tension (tense, relaxed, it's difficult to answer).
3. Vivacity (vigorous, languid, it's difficult to answer).
4. Mood (good, bad, it's difficult to answer).
5. Satisfaction from the work (satisfied, not satisfied, it's difficult to answer).
6. The degree of concentration of attention (attentive, absent-minded, it's difficult to answer).
7. The degree of excitation (exited, sleepy, it's difficult to answer).

The analysis of the results of the students 'state after the work with TZ and TEC program has shown:

- A significant advantage of TZ over TEC according to the parameters: «vivacity» (by 19 %), « satisfaction with the work » (by 24 %).
- An advantage of TZ over TEC according to the parameters: «state of health» (by 13 %), «mood» (by 11 %).
- The both programs have caused the same degree of tension.
- TZ has required a higher degree of concentration of attention and caused a greater excitation of the students. Apparently, it is explained by the fact, that on the results of his work with TZ the student is given a mark, but after the work with TEC marc is not given.

Conclusion

The results of the present research have shown the validity of the developed technique for an experimental estimation of the ergonomic parameters of CTP. The present investigation has carried out the control and a comparative analysis of the ergonomic parameters of a number of computer training programs on Electrical Engineering, one of the general engineering disciplines. The received results have shown the advantage of the TZ computer training program, which was worked out on the basis of the method of theoretical images over the TEC modeling program.

The account of the ergonomic aspects of perception of the information is very important for designing programs of educational purpose. Creating a comfortable interface, we shall promote the students ' effective mastering of the knowledge, form their positive attitude to the learning educational activity, what causes the adequate mobilization psycho-physiological processes, postpones the development of exhaustion, promotes a long and highly effective serviceability without damage to health.

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