Energetika universitetlari uchun axborot-o‘quv tizimlarini yaratishda kognitiv tizimlar tahlilini qo‘llanilish xususiyatlari

Nikolay N. Tsibov[1,a)], Jaloliddin T. Galbaev[1,b], Buboaisha B. Bekjanova[1,c], Asqarbek K. Qarmışaqov[1,d], Samat D. Umetaliev[1,e] Anvar G. Saidxodjayev[2]

[1,a)] DSc, prof., I. Razzakov nomidagi Qirg‘iz davlat texnika universiteti, Bishkek, 720024; Nikolay_research@mail.ru https://orcid.org/0000-0003-3196-0496

[1,b] DSc, professor, I. Razzakov nomidagi Qirg‘iz davlat texnika universiteti, Bishkek, 720024; jalal1603@mail.ru https://orcid.org/0000-0002-9460-2242

[1,c] Doktorant, I. Razzakov nomidagi Qirg‘iz davlat texnika universiteti, Bishkek, 720024; bb.bekzh@gmail.com https://orcid.org/0009-0000-3681-4055

[1,d] Texnika fanlari nomzodi, dots, I. Razzakov nomidagi Qirg‘iz davlat texnika universiteti, Bishkek, 720024; a.karmyshakov@kstu.kg https://orcid.org/0000-0003-3040-8480

[1,e] Katta o‘qituvchi, Elektromexanika kafedrasi, I. Razzakov nomidagi Qirg‘iz davlat texnika universiteti, Bishkek, 720024; samat_akilov@mail.ruhttps://orcid.org/0009-0008-2696-9932

[2] DSc, prof., Toshkent davlat texnika universiteti, Toshkent, 100095, O‘zbekiston; saidhodzaevanvar1@gmail.com

Dolzarbligi: Sun’iy intellektga ega bo‘lgan axborot-o‘quv tizimlarining jadal rivojlanishiga qaramasdan, texnik universitetlarda ularning didaktik samaradorligini ta’minlash muammosi hanuz to‘liq hal etilmagan. Shu sababli, texnik oliy ta’lim muassasalarida axborot-o‘quv tizimlaridan foydalangan holda ta’lim jarayonining sifatini va didaktik samaradorligini oshirish usullarini tahlil qilish va takomillashtirish bugungi kundagi dolzarb masalalardan biri hisoblanadi.

Ishning maqsadi: Energetika yo‘nalishidagi universitetlar uchun kognitiv avtomatlashtirilgan o‘quv tizimlarini loyihalash va qo‘llash orqali didaktik samaradorlikni oshirish.

Metodlar: Ta’lim jarayonining noaniqligi va nosimmetrikligi sababli, tadqiqotda kognitiv-tizimli, strukturaviy, ekspert, retrospektiv, faktoriyal, statistik, korrelyatsion, situatsion tahlil, PEST va SWOT tahlil uslublari qo‘llanilgan.

Natijalar: Mazkur maqolada axborot-o‘quv tizimlarining ishlash algoritmiga kognitiv tizim tahlilining teskari aloqa elementlarini qo‘shish orqali ularning didaktik samaradorligini oshirish usuli taklif qilingan. O‘quv vositalarining teskari aloqasi o‘quvchining yangi kognitiv sifatlarini va har xil murakkablikdagi virtual elektron qurilmalarning modellarini o‘z ichiga oladi; ular o‘quvchi tomonidan mustaqil loyihalash uchun taklif etiladi. O‘quv jarayonida yangi kognitiv sifatlarni rivojlantirish uchun shaxsiy xususiyatlarning har bir bosqichdagi nazorat sinovlari natijalariga asoslanib, A.V. Krutikov metodikasi asosida o‘quvchi super-egoning ta’siri bilan yuzaga kelgan irratsional salbiy qarashlarni bartaraf qilish bo‘yicha psixokorreksion mashg‘ulotlarda ishtirok etadi. Bunday salbiy qarashlar jamiyat ta’siriga bo‘lgan salbiy javob shakllarining yuzaga chiqishiga sabab bo‘ladi. Shuningdek, inson ongida mavjud bo‘lgan salbiy fikrlar ijodiy faoliyatga bo‘lgan kognitiv qobiliyatlarni sezilarli darajada pasaytiradi.

Kalit so‘zlar: kognitiv axborot tizimlari, kognitiv tizim tahlili, didaktik samaradorlik, o‘qitishning psixologik omillari, shaxsga yo‘naltirilgan yondashuv.

For citation: N.N. Tsybov, Zh.T. Galbaev, B.B. Bekzhanova, A.K. Karmyshakov, S.D. Umetaliev, A.G. Saidkhodjayev. Features of the application of cognitive systems analysis in the creation of information training systems for energy universities. Scientific and technical journal of Problems of Energy and Sources Saving, 2025, no. 3, pp. 10-21.
https://doi.org/10.5281/zenodo.16935106

Received: 12.07.2025
Revised: 24.07.2025
Accepted: 10.08.2025
Published: 23.08.2025

Особенности применения анализа когнитивных систем при создании информационно-обучающих систем для энергетических вузов

Николай Н. Цыбов[1,а)], Жалалидин Т. Галбаев[1,б] Бубуайша Б. Бекжанова[1,с], Аскарбек К. Кармышаков[1,д], Самат Д. Уметалиев[1,е], Анвар Г. Саидходжаев[2]

[1,а)] DSc, проф., Кыргызский государственный технический университет им. И. Раззакова, Бишкек, 720024; Nikolay_research@mail.ru https://orcid.org/0000-0003-3196-0496

[1,б] DSc, проф., Кыргызский государственный технический университет им. И. Раззакова, Бишкек, 720024; jalal1603@mail.ru https://orcid.org/0000-0002-9460-2242

[1,с] Докторант, Кыргызский государственный технический университет им. И. Раззакова, Бишкек, 720024; bb.bekzh@gmail.com https://orcid.org/0009-0000-3681-4055

[1,д] Кандидат технических наук, доц, Candidate of Technical Sciences, Associate Professor, Кыргызский государственный технический университет им. И. Раззакова, Бишкек, 720024; a.karmyshakov@kstu.kg https://orcid.org/0000-0003-3040-8480

[1,е] Старший преподаватель, кафедра электромеханики, Институт энергетики, Кыргызский государственный технический университет им. И. Раззакова, Бишкек, 720024; samat_akilov@mail.ruhttps://orcid.org/0009-0008-2696-9932

[2] DSc, проф., Ташкентский государственный технический университет, Ташкент, 100095, Узбекистан; saidhodzaevanvar1@gmail.com

Актуальность: Несмотря на стремительное развитие информационно-обучающих систем с искусственным интеллектом, проблема дидактической эффективности их применения в технических вузах остается нерешённой. Поэтому актуальной задачей является анализ и разработка методов повышения дидактической эффективности и качества образовательного процесса в технических университетах с

использованием информационно-обучающих систем.
Цель работы: Повышение дидактической эффективности проектирования и применения когнитивных автоматизированных обучающих систем в энергетических вузах.
Методы: В связи с нелинейностью и непредсказуемостью образовательного процесса основными подходами в исследовании выступили когнитивно-системный, структурный, экспертный, ретроспективный, факторный, статистический, корреляционный, ситуационный, PEST-анализ и SWOT-анализ.
Результаты: В работе предложен метод повышения дидактической эффективности использования информационно-обучающих систем путём включения элементов когнитивного системного анализа с обратной связью в алгоритм функционирования учебных электронных устройств. Обратная связь информационно-обучающих средств включает новые когнитивные качества обучающегося и модели виртуальных электронных устройств различной сложности, предлагаемых обучающемуся для проектирования. С целью развития новых когнитивных качеств в процессе обучения, по результатам каждого этапа контрольного тестирования личностных характеристик, студент по методике А. В. Крутикова проходит психокоррекционную работу по устранению иррациональных негативных установок, обусловленных влиянием суперэго. Такие установки являются причиной проявления негативных форм реакции на влияние общества. Кроме того, наличие негативных установок в сознании человека значительно снижает когнитивные способности к творческой деятельности.
Ключевые слова: когнитивные информационные системы, когнитивный системный анализ, дидактическая эффективность, психофакторы обучения, личностно-ориентированный подход.

Features of the application of cognitive systems analysis in the creation of information training systems for energy universities

Nikolai N. Tsybov[1,a], Zhalalidin T. Galbaev[1,b], Bubuaisha B. Bekzhanova[1,c], Askarbek K. Karmyshakov[1,d], Samat D. Umetaliev[1,e], Anvar G. Saidkhodjayev[2]

[1,a] DSc, prof., Kyrgyz State Technical University I. Razzakov, Bishkek, 720024; Nikolay_research@mail.ru https://orcid.org/0000-0003-3196-0496
[1,b] DSc, prof., Kyrgyz State Technical University I. Razzakov, Bishkek,720024; jalal1603@mail.ru https://orcid.org/0000-0002-9460-2242
[1,c] PhD student Kyrgyz State Technical University I. Razzakov, Bishkek, 720024; bb.bekzh@gmail.com https://orcid.org/0009-0000-3681-4055
[1,d] Candidate of Technical Sciences, Ass. Prof., Kyrgyz State Technical University I. Razzakov; Bishkek, 720024; a.karmyshakov@kstu.kg https://orcid.org/0000-0003-3040-8480
[1,e] Senior Lecturer, Department of Electromechanics, Power Engineering Institute,, Kyrgyz State Technical University I. Razzakov; 720024; samat_akilov@mail.ru https://orcid.org/0009-0008-2696-9932
[2] DSc, prof., Tashkent State Technical University, Tashkent, 100095, Uzbekistan; saidhodzaevanvar1@gmail.com

Relevance: Despite the rapid development of information training systems with artificial intelligence, the problem of didactic efficiency of their application in technical universities has not yet been solved. Therefore, an urgent task is the analysis and development of methods for improving the didactic efficiency and quality of the educational process in technical universities using information-training systems.
The purpose of this work is to improve the didactic efficiency of designing and applying cognitive automated training systems for power engineering universities.
Methods. Due to the nonlinearity and unpredictability of the educational process, the main approaches in the research were cognitive-systemic, structural, expert, retrospective, factorial, statistical, correlation, situational, PEST analysis and SWOT analysis.
Results. This paper presents a method for improving the didactic efficiency of using information-training systems by including elements of cognitive system analysis with feedback in the algorithm of functioning of training electronic devices. The feedback of information training tools includes new cognitive qualities of the student and models of virtual electronic devices of varying complexity, which are offered to the student for design. In order to develop new cognitive qualities in the learning process, based on the results of each stage of control testing of personal characteristics, the student, according to the method of A.V. Krutikov, participates in psychocorrectional work to eliminate irrational negative attitudes caused by the influence of the superego. Such negative attitudes are the cause of the manifestation of negative forms of response to the influence of society. Moreover, the presence of negative attitudes in the mind of a person significantly reduces cognitive abilities for creative activity.
Keywords: cognitive information systems, cognitive systems analysis, didactic efficiency, psychofactors of learning, personality-oriented approach.

1. Введение (Introduction)

Modern information training systems with artificial intelligence have a common drawback - low didactic efficiency. This is especially true for information training systems for technical universities. The reason for this is the position of the developers, according to which, information-training tools during design are perceived by developers only as technical devices and the main accents of attention are focused only on new technical solutions of the developed electronic devices. With such a narrow technical approach to design, the main goal of creating an information training system is not fulfilled - didactically effective transfer of new knowledge. One of the ways to increase the didactic efficiency of the designed technical training tools is the use of cognitive systems analysis, in which the information technical system is considered as a cognitive system. Any cognitive technical system is a multi-level hierarchical system of perception and processing of information about the external world, and the methods of cognitive systems analysis of the system are focused on the study of its subject area.

Researchers attribute the beginning of the implementation of the creation of information automated training systems to the works of B.F. Skinner, who in 1954 proposed the concept of linear programming and the works of N.A. Krowder, who in 1960 proposed the concept of branched programming [1, 2].

In the early nineties of the last century, information systems appeared that had the functions of adaptation to students and this already laid the foundation for the possibility of using a personality-oriented approach in education when using technical training tools [3]. Nevertheless, for the implementation of a personality-oriented approach, the results of diagnostics of the personal characteristics of students are necessary, which must be taken into account by the information system when forming the algorithm of the systems functioning. However, for the entire period of the creation of information training tools, there have been no serious attempts to apply the results of psychodiagnostics in the algorithms of automated training systems. An exception is some information systems that take into account only the psycho-emotional state of the student [4].

To achieve the goals of increasing the didactic efficiency of the technical teaching aids used, formalized results of a comprehensive systems analysis are required. As a variant of such a comprehensive system analysis, N.V. Sofronova provides in her work [5], where she examines the features of analyzing pedagogical systems using “cognitive system, structural, expert, retrospective, factor, statistical, correlation, situational, PEST analysis and SWOT analysis” [5, p. 579]. V.G. Minenko believes that the basis for analyzing pedagogical technologies should be qualimetric methods of analysis in combination with experimental testing [6]. In order to study the dynamics of the functioning of the information system, T.A. Tkalich proposes using the method of cognitive analysis using functional graphs [7]. When identifying the specific features of the educational process, researchers traditionally use a cognitive system approach aimed at studying the hypothesis about the functioning of the object under study. One of the methods for studying cause-and-effect relationships when predicting the pedagogical situation under study is the construction of cognitive maps. The cognitive map, as well as the cognitive model, is presented in the form of a functional graph. This approach to the system analysis of the educational process has limitations in the accuracy of the situation diagnostics, since the completeness of checking such a cognitive model for adequacy depends on the completeness of the basic knowledge, which, as a rule, is always insufficient.

The most significant for our research are the works of E.V. Lutsenko on the creation of automated system-cognitive analysis (ASC-analysis), which is presented by the author of ASC-analysis as a method of scientific knowledge using artificial intelligence. According to the concept of E.V. Lutsenko, “scientific knowledge is carried out by creating a model of the object of knowledge and studying its model”. In this case, the adequacy of the model is set as a condition, which should correctly reflect the properties of the object [8, 9]. The advantage of ASC-analysis is that the system analysis is structured not by stages, but by basic cognitive operations, which makes it possible to create various combinations of system analysis for different purposes. E.V. Lutsenko proposed the following basic operations for these purposes “– login assignment, perception, synthesis, abstraction, adequacy assessment, forecasting, deduction, classification, comparison, decision-making” [8-10]. ASC analysis by E.V. Lutsenko is essentially, an “analysis structured according to basic cognitive operations” [10, p. 20].

2. Методы и материалы (Methods and materials)

Due to the multifaceted and nonlinear nature of the educational process, the basis of our research in the study of information training systems is cognitive system analysis, but more complete information in the study of pedagogical situations and the educational process as a whole is provided by the integrated use of individual components of the following types of analysis "- cognitive system, structural, expert, retrospective, factor, statistical, correlation, situational, PEST analysis and SWOT analysis". For each stage of the study of the functioning of the information training system, it is advisable to use the type of analysis oriented to the local research task. With a general methodological approach and identifying the links between the components, the methods of system and structural analysis are effective. When assessing and monitoring the functioning of the system, it is advisable to use expert analysis. Retrospective analysis has proven itself well in identifying problems in operation. Due to the nonlinearity and unpredictability of the pedagogical process, when studying the qualitative characteristics of educational components and identifying cause-and-effect relationships between the components, the use of cognitive analysis is effective. When analyzing and comparing the results of the educational process, correlation and statistical analysis will be useful. Due to the unpredictability of the pedagogical process in cases of external environmental impact, to which the system is unable to respond, a situational analysis is necessary using PEST analysis and SWOT analysis, which assesses the "strengths and weaknesses of the development of the object under study in their interaction."

3. Результаты и обсуждение (Results and discussion)

At present, traditionally systemic cognitive analysis of educational technologies using automated technical means is used in monitoring, control, forecasting the quality of education, as well as in decision-making in conditions of nonlinearity and unpredictability of the educational process. Methods for applying automated systemic cognitive analysis in decision-making and monitoring the quality of the educational process are described in detail by E.V. Lutsenko in his works on automated system analysis (ASC analysis) [8-10].

In our work, we propose to expand the scope of application of cognitive systemic analysis methods in the creation of information training systems for technical universities.

In accordance with the ASC analysis procedures, at the initial stage of cognitive systemic analysis, a formalizable cognitive concept is created, the subject area is formalized, the subject area models are synthesized, and the research object is verified and analyzed. Then, we propose to apply improved systemic cognitive analysis with feedback directly in the functioning algorithm of the information training system. The feedback of information training tools includes new cognitive qualities of the student and models of virtual electronic devices of varying complexity, which are offered to the student for design. In this case, new cognitive qualities of the student are formed based on the results of psychocorrectional work carried out according to the methodology of A.V. Krutikov [11]. Psychocorrectional work to improve the personal qualities of the student is carried out based on the results of psychodiagnostics, which reveals the level of influence of psychofactors influencing the educational process. Psychofactors influencing the educational process characterize the impact of irrational negative attitudes caused by the influence of the superego. The presence of negative attitudes in a person's consciousness significantly reduces cognitive abilities for creative activity. Negative attitudes themselves are the cause of the manifestation of negative forms of personality response to the influence of society.

In order to develop new cognitive qualities in the learning process, based on the results of each stage of control testing of personal characteristics, the student, using the method of A.V. Krutikov, participates in psychocorrectional work to eliminate irrational negative attitudes caused by the influence of the superego.

In these studies, the results of psychodiagnostics are used not only to conduct psychocorrectional work, but also to form new elements of system analysis - cognitive elements of psychofactors. As a result of introducing new elements into system analysis, we obtain an expanded functionality of system analysis with new qualities.

In order to create an information training system using cognitive methods of training with feedback, we propose a concept of a method for designing electronic devices using elements of cognitive system analysis, which is used to teach students circuit design of complex electronic devices.

For each branch of scientific research, an application is made to technical universities for the necessary profiles of engineering activity. Then, technical universities prepare design engineers for special design bureaus. In the traditional concept of training developers of highly complex electronic devices, the design engineer, as a rule, repeatedly participates in the design of devices for three to seven years, during which the engineer improves his qualifications to the level of a highly trained specialist.

To solve the problem of training high-level specialists, a systemic approach is proposed using the methodology of systemic cognitive analysis. The structural diagrams of the traditional and proposed concepts are presented in Figure 1. Unlike the traditional concept, the proposed concept does not impose increased requirements on the engineer's qualifications. Ordinary engineers and even young specialists and students can be involved in the design. The design engineer is actively involved in systemic design, the cognitive feedback of which includes personal characteristics and psychofactors of the developer of an electronic device. During the design, the developer participates in the management of the design training process, in which he gradually improves the technical characteristics of the designed device and simultaneously improves himself as a specialist. And then the object becomes the subject of the design process. At the same time, based on the results of each stage of psychodiagnostics, the designer works to improve his personal qualities using the method of A.V. Krutikov [11]. The designer is trained in circuit design using training electronic devices that take into account the psychofactors and results of the academic training of the developer.

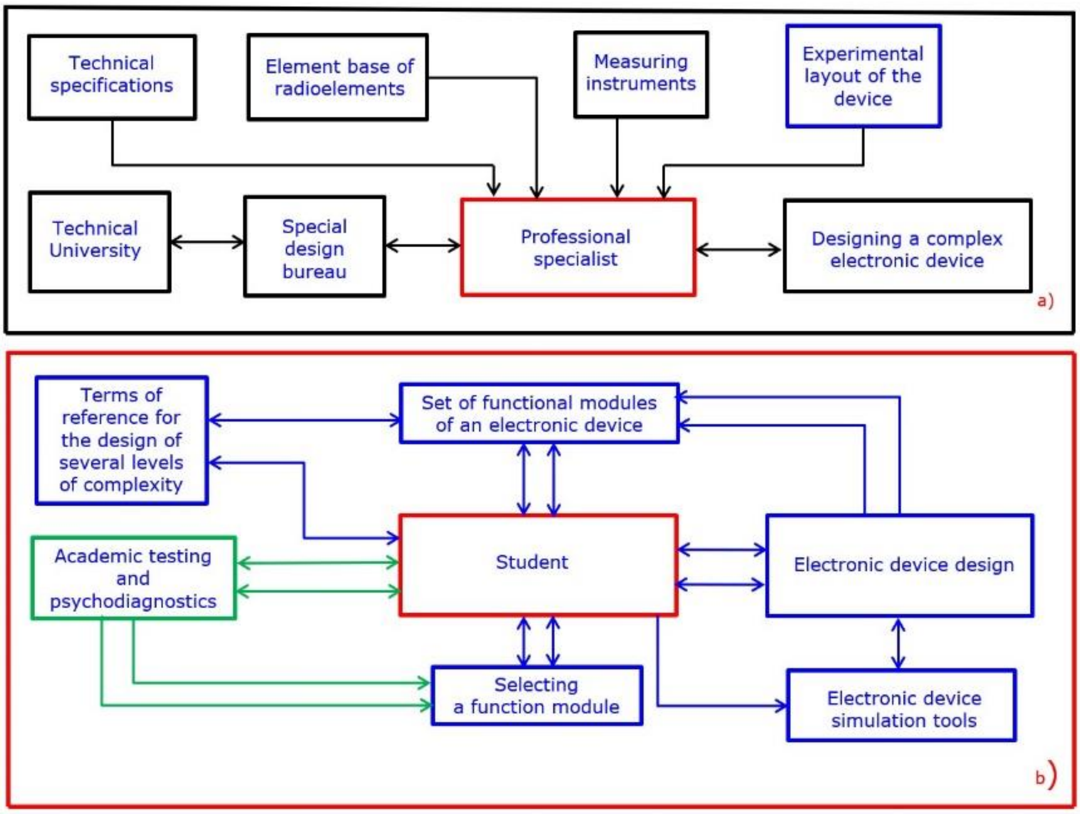

Fig 1. Traditional (a) and proposed (b) concepts of methods for designing electronic devices, using elements of cognitive systems analysis

The algorithm of functioning of electronic training devices, shown in Figure 2, is as follows. An electronic training device for teaching electronic device design uses a system analysis technique with cognitive feedback. The feedback of the software and hardware of the information training system includes models of electronic units of varying complexity, as well as the cognitive qualities of the developer of electronic equipment.

Electronic training devices contain a main control part that provides algorithms for controlling the device and a variable part in the form of ten modules of varying complexity similar in functionality, which are offered to the student for design. The most complex module offered to the student for design is confirmed by a patent for an invention.

The training electronic device receives information from the psychodiagnostic unit on the personal characteristics of the student in the form of ten levels of the student's readiness to develop electronic units of a certain complexity.

Based on the results of psychodiagnostics and academic testing, the electronic training device offers the student one of ten options for built-in modules.

Based on the results of the primary psychodiagnostics and primary academic testing, the student is offered a simple model of an electronic unit for development. The student calculates the parameters of the electronic components of the proposed device, and models the developed unit in one of three software environments.

The model of the electronic unit developed by the student is evaluated by the training device and, based on the results of the work analysis, the student is offered to create a similar unit of higher complexity with improved characteristics. The improved model of the electronic unit is also evaluated by the training device and, based on the results of the analysis, the student is offered to design a unit of even greater complexity. The final result is the student designing a highly complex electronic unit, the technical solution of which has scientific novelty and is confirmed by a patent for an invention. Such a methodology of system analysis, applied in the training device, assumes a real output in the form of new technical solutions. The proposed concept of circuit design assumes mandatory psychocorrectional work of students based on the results of psychodiagnostics. For these purposes, it is necessary to identify psychofactors that affect the learning process in a specific training profile. The set of identified psychofactors for humanitarian and technical universities will be different depending on the specifics of the disciplines studied. In our case, for the purposes of circuit design of electronic devices, from the seventy-seven psychofactors proposed by teachers and psychologists, five main and fourteen additional psychofactors influencing the educational process were identified using correlation analysis. The magnitude of the influence of psychofactors on the academic performance of students studying circuit design is determined using the Spearman rank correlation method:

$$\rho = 1 - 6\frac{\sum d^2}{n^2 - n}, \quad (1)$$

where *ρ* is the Spearman correlation coefficient; *d2* is the square of the difference in ranks of the criteria under study; *n* is the number of criteria.

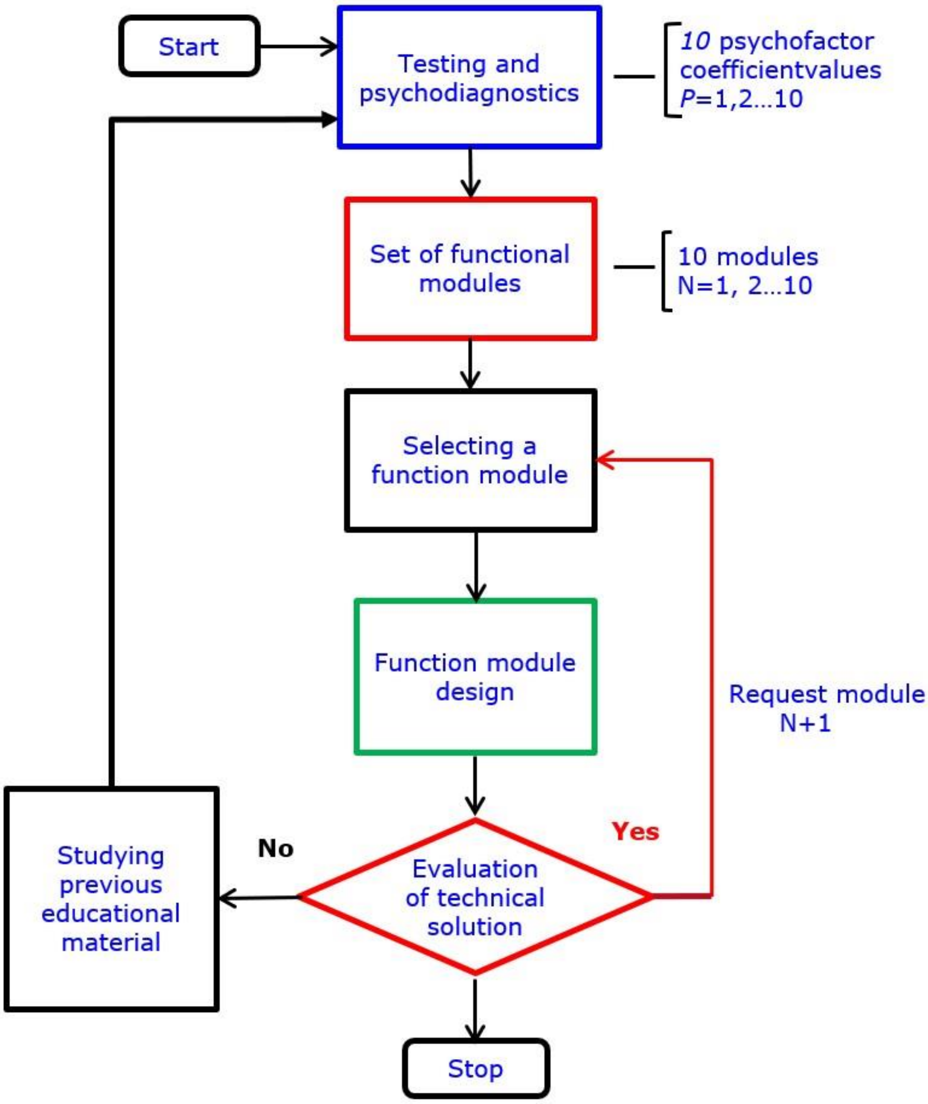

Fig. 2. Algorithm for the functioning of the training device

Table 1 and Figure 3 show the results of the correlation analysis of psychofactors.

As can be seen from Table 1 and Figure 3, the dependence of the studied features between academic performance and the results of testing psychofactors is statistically significant only for the first five psychofactors. According to the Chaddock scale, the strength of the connection between the first five psychofactors is high, the values of the correlation coefficients are *ρobs>ρcrit*, therefore the dependence of the features is statistically significant *(p<0.05)*.

Table 1. Spearman's rank correlation coefficients between academic performance and psychofactor testing results.

№ psychofactor	Name of the psychofactor	Correlation coefficient ρ
1	2	3
1	Personality dependence on all types of fears	0,892
2	Personality dependence on material excesses	0,826
3	Personality dependence on inflated self-esteem	0,882
4	Responsibility for one's actions	0,809
5	Personality dependence on low self-esteem	0,779
6	Understanding	0,193
7	Remembering	0,150
8	Comprehension and assimilation	0,180
9	Focus on content	0,160
10	Activity of the leading type of memory	0,150
11	Depression	0,156
12	Irritation	0,141
13	Resentment	0,136
14	Guilt	0,110
15	Verbal dependence	0,072
16	Emotional dependence	0,080
17	Dependence on achievements	0,041
18	Self-demanding	0,050
19	Demanding of others	0,060

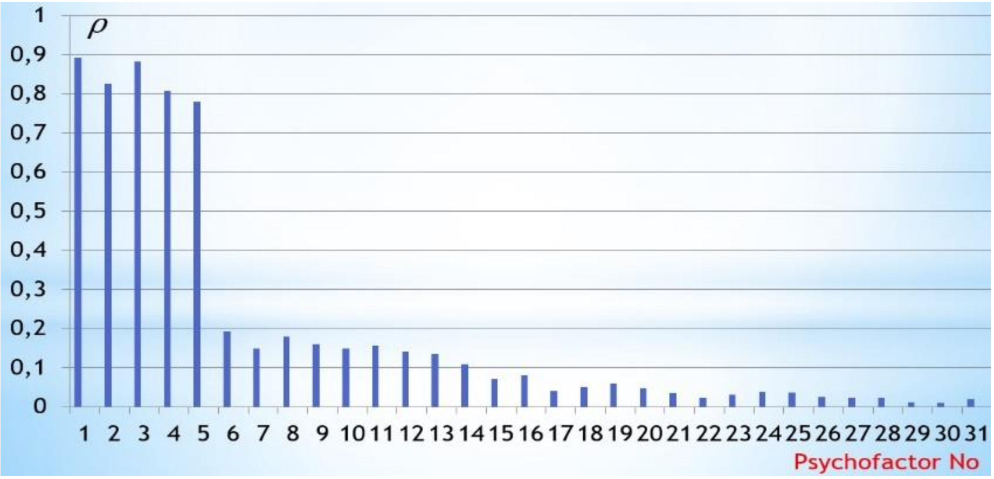

Fig. 3. Correlational relationship between academic performance and psychofactors

According to the concept of the author of the correctional method A.V. Krutikov, the first psychofactor is the main one [11]. This psychofactor is the cause of the formation of all other psychofactors. Therefore, the correlation analysis was carried out relative to the first main psychofactor (see Fig. 4 and Table 2).

According to the conducted correlation analysis, a dependence was revealed only between the first five psychofactors. In accordance with the Chaddock scale, the strength of the connection between them is high, the values of the correlation coefficients $\rho_{obs} > \rho_{crit}$, therefore the dependence of the features is statistically significant ($p<0.05$).

According to the conducted correlation analysis, five main psychofactors and fourteen additional ones, from the sixth to the nineteenth psychofactor, were identified.

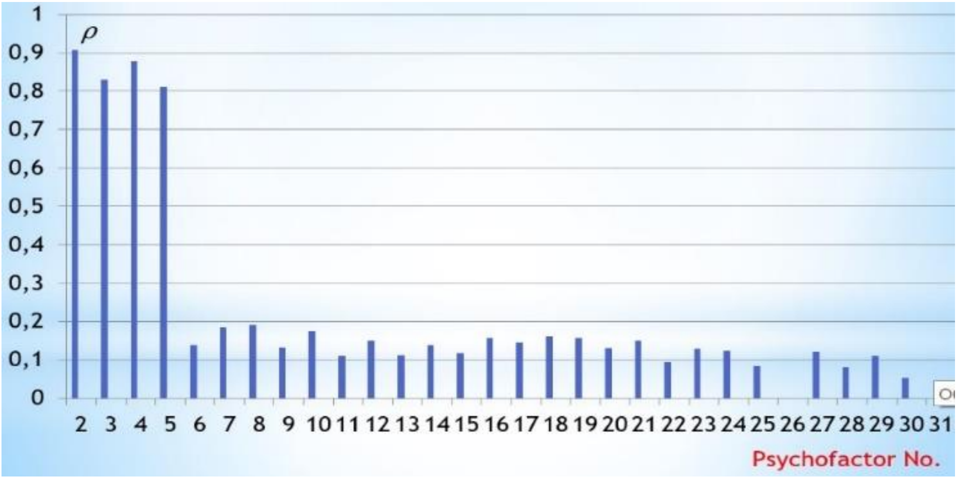

Fig. 4. Correlation between psychofactors

Table 2. Spearman's rank correlation coefficients between the main first and other psychofactors

№ psycho-factor	Coeffic. Correlat. ρ	№ Psychof.	Coeffic. Correlat. ρ	№ Psychof.	Coeffic. Correlat. ρ	№ Psychof.	Coeffic. Correlat. ρ
1	2	3	4	5	6	7	8
1	0,908	21	0,096	41	0,124	61	0,111
2	0,831	22	0,130	42	0,079	62	0,089
3	0,877	23	0,124	43	0,092	63	0,071
4	0,811	24	0,084	4	0,118	64	0,124
5	0,138	25	0,073	45	0,057	65	0,092
6	0,187	26	0,121	46	0,073	66	0,079
7	0,191	27	0,083	47	0,084	67	0,062
8	0,133	28	0,111	48	0,113	68	0,114
9	0,174	29	0,054	49	0,089	69	0,097
10	0,110	30	0,072	50	0,116	70	0,069
11	0,150	31	0,091	51	0,087	71	0,093
12	0,112	32	0,037	52	0,108	72	0,104
13	0,138	33	0,072	53	0,059	73	0,076
14	0,119	34	0,104	54	0,113	74	0,092
15	0,157	35	0,077	55	0,102	75	0,079
16	0,146	36	0,046	56	0,073	78	0,058
17	0,162	37	0,112	57	0,094	77	0,062
18	0,158	38	0,084	59	0,037		
19	0,132	39	0,075	59	0,108		
20	0,151	40	0,046	60	0,081		

Correlation analysis showed that when psychodiagnostics of personal characteristics of students, it is necessary to take into account the first five psychofactors and, according to the recommendations of the university psychologist, supplement the set of psychofactors from the list from the sixth to the nineteenth psychofactor.

According to the algorithm of the functioning of the electronic training device, the result of psychodiagnostics is used to form the cognitive elements of psychofactors and to form a generalized criterion for testing psychofactors, the value of which determines the level of complexity of the task option for the level of complexity of the designed module.

The generalized criterion of psychofactors is formed based on the results of the convolution of criteria into one generalized criterion of psychofactors.

In this work, the convolution of psychofactors was carried out using the Fishburn method.

The weighting coefficients of psychofactors are determined from the expression:

$$w_i = \frac{2\cdot(n-i+1)}{n(n+1)}, \tag{2}$$

where *w* is the weight coefficient of the psychofactor; *n* is the number of psychofactors; *i*=1,….*n*.

The generalized criterion of psychofactors is determined from the expression:

$$k_{Ps} = \sum_{i=1}^{n} w_i k_i \; , \tag{3}$$

where *kPs* is a generalized criterion of psychofactors; *w* is a weight coefficient of a psychofactor; *n* is a number of psychofactors*; i=1,….n.*

When designing automated cognitive training systems and their training modules, it is necessary to monitor the quality of the educational process at each stage. Quality control involves various approaches, according to which researchers understand the quality of the educational process as levels of professional qualifications, upbringing and social preparation [12].

The main difficulties in monitoring and controlling the quality of training are associated with the nonlinearity and unpredictability of the learning process. Therefore, when creating an expert model of the quality of the educational process for teaching circuit design, it is necessary to have modules for psychodiagnostics of personal characteristics and modules for testing the student's academic preparation in the software and hardware.

The expert model for monitoring and controlling the quality of training in our studies was obtained based on improving the quality model of S. A. Gordienko, presented below in expressions (4-6) [13, 14]:

$$K_{noд} = v_i = v_з + (v_з - v_0) \times f_t(\Delta\theta, P_{omo}, T) \; , \tag{4}$$

where *vj* is the relative coefficient of the student's preparation based on the results of the *j-th* lesson. The relative coefficient of the student's preparation is the intensity of the error flow (incorrect answers) identified based on the results of the *j-th* lesson; *vj* varies from one to zero. One corresponds to 100% of incorrect answers. Zero corresponds to the absence of incorrect answers; *v0* is the relative coefficient of the student's academic preparation at the beginning of the training. Variates from zero to one; *vз* is the specified relative coefficient of the student's academic preparation. Variates from zero to one; $\Delta\Theta$ is the duration of the knowledge teaching cycle during the *j-th* lesson, in hours; *T* is the total training time in hours; *j* =1, 2, 3,…*n* is the number of lessons according to the training plan; is the function corresponding to the error flow; P_{omo} is the generalized coefficient of the efficiency of the training process using information technology.

$$K_{efcom} = P_{omo} = R_{3H} \cdot \left[1 - (e^{-(\delta_{j-1})\cdot\Delta t_j \cdot} - (1 - e^{-(\delta_{j-1})\cdot\Delta t_j}) \cdot q_j) \right] . \tag{5}$$

The relative coefficient of a student's preparation based on the results of the *j-th* lesson can be found from the expression:

$$v_i = (v_з - v_0) \cdot \prod_{j=1}^{j} (1 - \Delta t_j \cdot R_{3H.} \cdot \left[1 - (e^{-(\delta_{j-1})\cdot\Delta t_j} - (1 - e^{-(\delta_{j-1})\cdot\Delta t_j \cdot}) \cdot q_i) \right]) . \tag{6}$$

where δ is the relative coefficient of perception of the understood material at the end of the *j-1* lesson. It varies from zero to one; *q* is the feedback coefficient, which characterizes the identification of correct answers at the beginning of the *j-th* lesson. It varies from zero to one. At one, all answers are correct; Δtj is the relative coefficient of training time. As the number of lessons increases, the coefficient increases from zero to 1 and is calculated using the formula:

In order to improve the model of the expert system of the quality of the learning process proposed by S.A. Gordienko, we will introduce new coefficients into expressions (5) and (6), taking into account academic preparation, the results of psychodiagnostics and new cognitive qualities based on the results of psychodiagnostics and correctional work.

The newly introduced coefficient of psychofactors *P* affects the perception of the studied material.

The coefficient of psychofactors *P* has ten values and changes from 0 to 1. The newly introduced coefficient of the results of psychodiagnostics *P* takes into account the identified personal characteristics of the student and the level of academic training of the student. The coefficient of psychofactors *P* is characterized by ten levels of the student's readiness to design a certain complexity. The first level corresponds to the lowest level of the student's preparation for circuit design. The tenth level corresponds to the highest level of the student's preparation for circuit design.

The newly introduced coefficient of feedback *F* takes into account the student's choice of a functional unit of the corresponding complexity.

The training simulator contains a set of functional electronic units of ten levels of complexity. Therefore, the coefficient of feedback *F* also has ten values corresponding to ten levels of complexity of the units proposed for design.

The coefficient of feedback *F* displays the identification of correct answers at the beginning of the *j-th* lesson.

Taking into account the newly introduced coefficient P, the relative coefficient of perception of the understood material δ can be found from the expression:

$$\delta_j = (1 - e^{-P_{j-1}}) . \tag{7}$$

Taking into account the newly introduced coefficient F, which takes into account the student's choice of a functional unit of the corresponding complexity, the feedback coefficient q can be found from the expression:

$$q_j = B_0 (1 - e^{-F_j}) , \tag{8}$$

where *B0* is the coefficient of identifying correct answers at the beginning of the *j-th* lesson.

Taking into account the newly introduced coefficients, the generalized coefficient of the efficiency of the learning process when using P_{omo} information technology tools and the relative coefficient of the student's academic preparation based on the results of the *j-th* lesson will take the following form:

$$P_{omo(j)} = R_{3H} \cdot \left[1 - (e^{-(1-e^{-P_{j-1}})\cdot\Delta t_j} - (1 - e^{-(1-e^{-P_{j-1}})\cdot\Delta t_j}) \cdot B_0 (1 - \mathrm{e}^{-Fj})) \right], \tag{9}$$

$$v_j = (v_з - v_0) \cdot \prod_{i=1}^{j} (1 - \Delta t_i \cdot R_{3H.} \cdot \left[1 - (e^{-(1-e^{-P_{i-1}})\cdot\Delta t_j} - (1 - e^{-(1-e^{-P_{i-1}})\cdot\Delta ti}) \cdot B_0 (1 - e^{-F_i})) \right], \tag{10}$$

where $R_{зн}$ is the degree of previously acquired knowledge.

Substitute the numerical values into expressions (9), (10).

Numerical values of the variables:

$\Delta\Theta$ – 32 hours; T – 32 hours; $v_з$ =0.95; v_0=0.1; *j* from 0 to 16 (0, 1, 2, 3…16); *R*зн =0.9; B_0 changes from *0 to 1*; δ_j changes from *0 to 1*; *qj* changes from 0 to 1; Δt_j changes *from 0 to 1 (0; 0.0625; 0.125; 0.250; …1* with a step of *0.0625);* P_j changes from *0 to 1* (10 values with a step of 0.1); *Fj* changes from *0 to 1.3* (10 values with a step of 0.13).

As a result of the accepted numerical values, according to the calculation results, we obtain the dependencies of the generalized coefficient of the efficiency of the design training process using information technology tools and the relative coefficient of the student's preparation, which is the intensity of the error flow (incorrect answers) identified based on the results of the *j-th* lesson.

The obtained dependencies of expressions (9) and (10) are the initial data when monitoring the quality of the training process.

Figures 5 and 6 show graphs of families of curves of the generalized coefficient of the efficiency of the design training process using information technology tools P_{omo} and the relative coefficient of the student's preparation *vj* family of curves for different values of the coefficient of psychofactors (P) for different values of the coefficient of psychofactors (P).

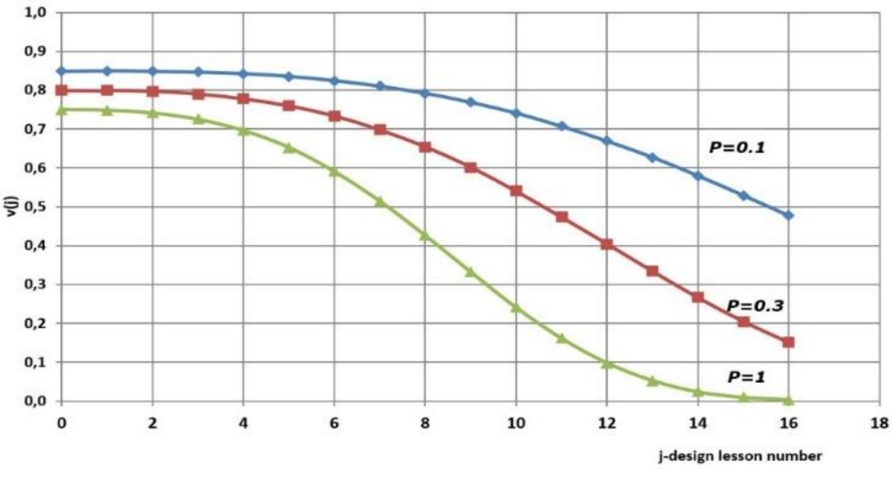

Fig. 5. Dependence of v_j on j for different values of the coefficient of psychofactors *P*. Dependence of v_j on *j* for different values of the psychofactor coefficient *P: v(j)* at *P=0.1; Rkn=0.9; Bo=0,5;* v_0*=0,1; v(j)* at *P=0,3; Rзн=0,85; Bo=0,5;* v_0*=0,15; v(j)* at *P=1; Rзн=0,9; Bo=1* v_0*=0,2*

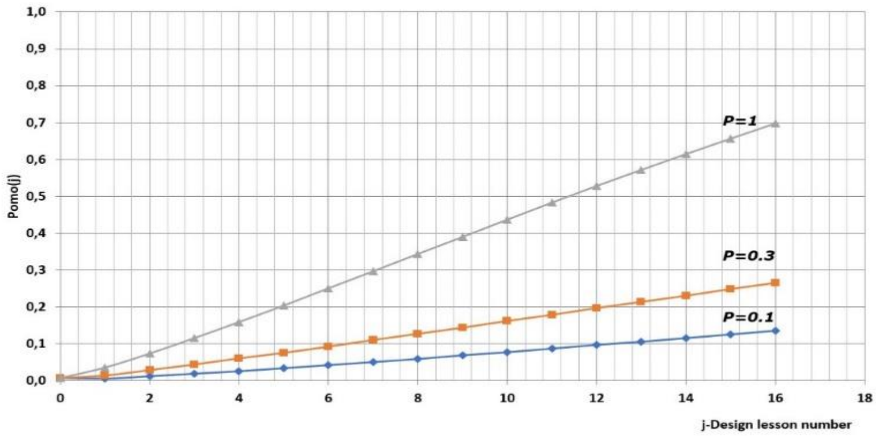

Fig. 6. Dependence of *Pomo* on *j* for different values of *P*. Dependence of *Pomo* on *j* for different values of *P: Pomo(j)* for *P=0.1, Rkn=0.9, Bo=0.5, v0=0.1; Pomo(j)* for *P=0.3, Rkn=0.85, Bo=0.5, v0=0.15; Pomo(j)* for *P=1, Rkn=0.9, Bo=1, v0=0.2*

4. Заключение (Conclusion)

1. The implementation of the didactic efficiency of designing and using cognitive learning systems is possible only if the developers perceive pedagogy not only as a subject area of knowledge, but also as a specific part of management theory.
2. Any educational process, with the use of automated learning tools and without technical means, in any case, should be based on a personality-oriented approach to education.
3. The cognitive learning system should contain automated monitoring and psychodiagnostics tools to identify the personal characteristics of students.
4. The use of psychodiagnostics results for the purpose of forming new additional elements of cognitive systems analysis expands the functionality of cognitive systems analysis and increases the efficiency of the learning system.

REFERENCES

1. Skinner, B. F. The science of learning and art of teaching [Text] / B. F. Skinner // *Harward Education Rev*. – 1954. – Vol. 24. – P. 86–97.
2. Karpova, I. P. History and Prospects of Development of Automated Learning *Systems [Electronic resource]* / I. P. Karpova. - Access mode: https://publications.hse.ru/mirror/pubs/share/folder/fy9jvqbotk/direct/83795635. -Title from the screen.
3. Tumbinskaia, M. V. Automated information systems in education as a tool for human-machine interaction: history and prospects [Text] / M. V. Tumbinskaia // *Proceedings of the Third International Conf. "Development of computing technology and its software in Russia and the former USSR: history and prospects"* (SoRuCom-2014). - M., 2014. - P. 369-376.
4. Mishina, V. E. Analysis and study of methods for automatic determination and control of the user's emotional state *[Electronic resource] / V. E. Mishina // Sovrem scientific research and innovation*. – 2017. – No. 4. – Access mode: URL: http://web.snauka.ru/issues/2017/04/80863. – Title from the screen.
5. Sofronova N.V. Methods of analysis of pedagogical systems. *Fundamental research.* 2013. No. 11-3. P. 578-583.
6. Minenko V.G., Khoroshun K.V., Romanova M.L., Bus T.V. Qualimetric methods of analysis of pedagogical technologies. *Scientific notes of P.F. Lesgaft University.* 2023. No. 2 (216). P. 292-296.
7. Tkalich T.A. Cognitive analysis of performance indicators of information systems. *Economics and Management (Minsk).* 2012. No. 3 (31). P. 93-99.
8. Lutsenko E.V. Universal cognitive analytical system "EIDOS". Krasnodar, 2014.
9. Lutsenko E.V., Loiko V.I., Baranovskaya T.P. Automated system-cognitive analysis - a promising tool for solving the problems of the digital society. In the collection: New quality of education and science: possibilities and prospects. *Collection of articles from the international scientific and practical conference. Research Institute of History, Economics and Law.* 2017. Pp. 113-117.
10. Lutsenko E.V. Problems and prospects of the theory and methodology of scientific knowledge and automated system-cognitive analysis as an automated method of scientific knowledge providing meaningful phenomenological modeling. *Polythematic online electronic scientific journal of the Kuban State Agrarian University.* 2017. No. 127. P. 1-60.

11. Krutikov, A. V. Personal psychologist. Synharmonic psychotraining *[Electronic resource] / A. V. Krutikov. - 2nd ed., revised and enlarged* - 2012. - 244 p. - Access mode: livemusik-nuernberg1.jimdo.com/russian/книги/ WV Weltall Verlag e.K. - Title from the screen.

12. Potashnik, M. M. Quality management of education [Text]: *practical orientation monograph and method. manual / M. M. Potashnik. - M .: Pedagogical Society of Russia*, 2000. - 448 p.

13. Tsybov, N. N. Analysis and formalization of the components of the quality of the educational process [Text] / N. N. Tsybov // Vestn. *Voronezh. in-ta high technologies*. - 2019. - No. 1 (28). - P. 147-152.

14. Gordienko, S. A. Using an expert system to calculate the indicator of theoretical training of a student [Text] / S. A. Gordienko, I. V. Trubachev, V. A. Yarmysh // *Innovative technologies in the educational process: materials of the XIX All-Russian scientific and practical. conf. - M*., 2017. - P. 55-60.