

# Differential Technique of Training on the Basis of Diagnostics of Students' Learning Capabilities

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## ABSTRACT

An author's differential technique of training has been developed, which presupposes the identification of individual typological differences of students (learning capabilities) and the development on this basis of strategies for organizing interaction between the teacher and the learner (student). Differential technique includes the following components: invariant (heuristic algorithmic prescription) and variable (learning strategies for five typological groups of students). The effective implementation of the differential technology is provided by a set of diagnostic training facilities with computer support, aimed at training the teacher and at ensuring the learning process.

## 1 Introduction

Analysis of scientific literature and pedagogical practice has shown that traditionally the study of the effectiveness of the organization of the learning process covers the parameters that study the "knowledge" characteristics of students. Not enough attention is paid to the cognitive, personal and activity characteristics of students in the organization of their learning process. We have not identified studies that contain consideration of these characteristics in the complex. The level of learning and the degree of academic achievement of students are still the most common indicators of the effectiveness of the organization of the learning process.

Thus, it seems to us expedient and relevant to develop a mechanism for systemic pedagogical diagnostics, which is aimed at studying the effectiveness of the organization of the learning process and is focused on the integrative parameter. The integrative parameter should reflect: systematic data on the cognitive, activity and personal development of students; information about the features of the teacher's pedagogical activities, as well as generalized information about the effectiveness of the organization of the learning process.

The practical significance of the study is to improve the organization of the learning process and the development of educational opportunities for students' personality.

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## **2 Body**

*Research hypothesis.* If we develop an integrative parameter that will allow measuring micro- and macro-shifts in the cognitive and personal development of a student and an adequate anthropological technique that is organically included in the learning process, then this will allow a comprehensive assessment of the educational effect and control of pedagogical interaction.

Research methods: analysis of scientific and methodical literature, creation of scientific substantiation, modeling of pedagogical phenomena; pedagogical observation, survey, programming; pedagogical experiment, analogy; element analysis, methods of mathematical statistics.

### **2.1 Theoretical foundations and description of differential technique**

The effectiveness of the organization of the learning process, in our opinion, must be studied on the basis of the parameter that characterizes the success of the student's development in the process of studying and cognitive activity.

The most important products, the results of the studying and cognitive process, researchers include: new images, a newly formed internal plan of action (P.I. Gal'perin), new systems of concepts (V.V. Davydov), the creation of new cognitive structures and the improvement of old, so-called – neoplasms (Z.I. Kalmykova, N.A. Menchinskaya). Some authors use as a parameter adequately reflecting the development in the process of learning, various synthetic characteristics: attitude to the teaching (M.N. Volokitina), methods and techniques of thinking (Y.U. Gromyko), a holistic knowledge system (L.Ye. Zorina), style of mental work (YU.A. Samarin), competence (J. Raven), the level of assimilation of the system of concepts (A.V. Usova), an educational product (A.V. Khutorskoy). I.F. Kharlamov actualized the task of organizing education as a process of personal development of students and the author considered the overall development of a student, including his potential abilities, as the result of studying and cognitive activity.

As established by a number of researchers (Vygotskiy, 1982), (Kalmykova, 1981), (Menchinskaya, 1989), (Talyzina, 1975), not the indicators of the achieved level of knowledge should be the main criteria for development in the learning process and the formation of certain properties, as the results of the assessment of the development possibilities of the subject in the course of mastering new material in terms of training. This implies the organization of training in order to expand and complicate the individual resources of the individual by means of learned knowledge.

Thus, the result (neoplasm), obtained in the process of learning, we will consider a certain increase in learning capabilities (potential resources) of the subject of study. This parameter is integrative.

The concept of “learning capabilities” was introduced into didactics in the 70s of the 20th century. Expanding this concept in various psychological and pedagogical contexts of Yu.K. Babansky (Babansky, 1987), Z.I. Kalmykova, L.M. Menchinskaya, I.I. Tsyrukun (Tsyrukun, 2000), M.V. Cheredov (Cheredov, 1973) emit different characteristics of this indicator.

Based on the analysis of the studied literature, the author of the article formulates the definition of the concept under consideration; highlighted two criteria (learnability, strength of study), as the most significant features of learning capabilities; indicators of each variable are defined (Tab.1).

*Learning capabilities* are an integrated anthropological parameter that reflects the achieved and potentially possible levels of development of pupil (students) in cognitive, activity and personal aspects, and also characterizes the degree of efficiency of the organization of their educational and cognitive activity.

Learning capabilities is a parameter that can be viewed as a system. Learnability and strength of study combine indicators of various levels of mental development (closest and actual) (L.S. Vygotskiy). This focuses the organization of the learning process on managing the development of student learning opportunities.

When building the learning process, the teacher should focus not only on the development cycles that have been completed (as is traditionally done at school), but should rely on the child's abilities determined by his nearest development zone. The potential of the student, entering the zone of proximal development, in the learning process, which is organized as the management of the development of its educational opportunities, moves into the zone of actual development. The dynamics of development in the learning process will be characterized by the rate of advancement of the student within the "zone of his learning capabilities." If the teacher does not have operational information about the level of educational opportunities of students, then it is impossible to organize effective training. "To teach a child what he cannot learn is just as useless as teaching him what he already knows how to do on his own." (Vygotskiy, p. 254).

Based on the presented theoretical foundations and previous studies, the author has developed and tested the Differential technique of training on the basis of diagnostics of students' learning capabilities. The parameter "learning capabilities" is presented as a system-forming element of the methods. Within the framework of the technique, it provides an opportunity to study three aspects of the learning process: the level and dynamics of the development of student learning capabilities; particular pedagogical activities of the teacher; the effectiveness of the organization of the learning process.

Table 1. The structure of the parameter "learning capabilities"

Dominant parameter	Criteria characterizing the parameter	Indicators	Indicator translation into dependent variables
Learning capabilities	learnability	degree of training	comprehension
			automation
			comprehension
		mastery of intellectual skills	understanding
			application
			analysis
			synthesis
			assessment
		cognitive independence	self-study skills
			cognitive motives
			cognitive initiative
			sensitivity to support
	strength of study	physical performance	strength of the nervous system processes
			health status
			fatigue
			interest in studies
			perseverance
			purposefulness

In the name of the developed technique, the term “differential” is used (from the Latin. Differentia - difference, difference), which means: different, unequal under different conditions. Differentiation is interpreted as “the side of the development process associated with the division, dismemberment of the developing whole into parts, steps, levels” (Il’ichev, other, p. 170). This emphasizes the specifics of the technique: it contains an invariant in the form of a heuristic algorithmic prescription, but its core is the pedagogical strategies for organizing the training of students of five typological groups aimed at developing different, unequal person taking into account different conditions.

The essence of the differential technique is the identification of individual-typological differences of students (their learning capabilities) and the development on this basis of strategies for organizing their training.

*The structure of the differential technique:*

- purpose;
- tasks;
- stages of implementation and auxiliary didactic tasks for each of them;
- projected result;
- diagnostic and educational units;
- invariant (heuristic algorithmic prescription) and the variable components (pedagogical strategies for organizing the learning process);
- the content of the training;
- diagnostic and training complex of tools with computer support.

In the implemented pedagogical experiment, the differential technique was applied both at the secondary level and at the higher education level. In these cases, the content of the training was changed. At the level of secondary education, it was a curriculum for students in grades 6-8. At the level of higher education, the formation of diagnostic competence in future teachers in the process of general pedagogical training. This article will present the data of a pedagogical experiment, in which students from the Vitebsk State University named after P.M. Masherov (120 students) and Belarusian State Pedagogical University named after Maxim Tank (110 students).

The stages of the implementation of the differential methods are associated with a long period and are related to the content of the preparation of the future teacher. Therefore, the following stages were singled out: “initial state”, “propaedeutics”, “school”, “creation”.

The differential technique includes components: invariant (heuristic algorithmic prescription) and variable (learning strategies for five typological groups of students). Consider them.

Based on the structure of pedagogical activity, we have revealed that diagnostics is the initial stage of the teacher’s professional activity in managing the learning process. It is also the final stage of solving a pedagogical problem. Thus, diagnosis prevails at the initial and final stages due to the fact that pedagogical activity is cyclical. In addition, diagnostic information as it permeates the entire structure of pedagogical activity, giving it a conscious and manageable character. Under these conditions, the adopted pedagogical decisions are based on objective diagnostic data characterizing the learner (student).

The author of this study for the differential technique developed an algorithm that allowed the organic inclusion of diagnostics (including computer support for the adopted pedagogical decisions) in the organization of the learning process.

Heuristic algorithmic prescription (algorithm):

1. system diagnostics of learning capabilities of students using computer diagnostics;
2. differentiation of students (weak, medium weak, medium, medium strong, strong typological groups);
3. choice for the typological group of an adequate strategy for the organization of the educational process (support, stimulation, guidance, cooperation, co-creation);

4. implementation of the pedagogical strategy in accordance with the dominant prescription model (relaxopedic, receptive, instrumental, culturological, research, innovative);
5. reflection of the effectiveness of the organization of the learning process;
6. definition of a new diagnostic query.

Pedagogical strategies are the core of differential technique, they take into account the peculiarities of typological groups of students. The strategy is refined by choosing a model-prescription (instructions), as well as a system of methods, forms and tools presented in the methodical maps of differential technique.

To implement the strategy, a tactic is selected (a form of consistent implementation of strategic plans taking into account the specified conditions) in which individual features of the resolution of the pedagogical situation and features of the teacher (student) manifest themselves.

In this study, the tactic for the implementation of the strategy is the model-prescription (Tsyrukun, 2000). If the pedagogical strategy determines the organizational scenario of interaction between the teacher and the student, the model-prescription is a technological and informative scenario of the students' studying and cognitive activity.

The author uses prescriptive strategies, but their content - prescription models - are characterized by different types of management of studying and cognitive activity for subjects of the learning process being organized (from teacher support to co-creation).

The author of the study identified five pedagogical strategies for organizing the learning process on the basis of the sign "nature of the management of students' studying and cognitive activity". The content of the selected strategies and the corresponding model-instructions correlate with the typological groups of students (Tab.2).

We present a description of strategies and model-prescriptions in the context of the process of forming diagnostic competence in students.

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Table 2. The ratio of typological groups of students with pedagogical strategies

<b>Cumulative index of "learning capabilities"</b>	<b>Typological group of students</b>	<b>Learning strategy</b>	<b>Model-prescriptions, adequate of pedagogical strategy</b>
$G \leq 0,26$	weak	support	Receptive and relaxopedic
$0,26 < G \leq 0,42$	medium-weak	stimulation	Receptive and instrumental
$0,42 < G \leq 0,58$	average	guide	Receptive, instrumental and relaxopedic as prior to culturological
$0,58 < G \leq 0,74$	medium strong	cooperation	Research and dialogue
$0,74 < G$	strong	co-creation	Cultural, research and innovation

Support strategy. The process of organizing training is based on the psychotherapeutic approach and direct management of studying and cognitive activity. The teacher with the help of correctional-compensatory principle of management concentrates the student on the features of diagnostic activities. The strategy is represented by receptive and relaxopedic model-prescriptions.

For a receptive prescription model, the following are characteristic:

- transfer to students of knowledge about the diagnosis in finished form;
- reproduction of acquired knowledge by students;
- reproduction by students of learned diagnostic operations;
- systematization of new knowledge and their comparison with previously obtained;
- demonstration of diagnostic operations (skill elements);
- streamlining of new knowledge;
- the organization of their application in a modified situation.

Relaxation model prescription involves the implementation of the following rules:

- creation of a positive attitude to the perception of the object of knowledge;
- bringing the student's consciousness into a comfortable state;
- creating a situation of success;
- organization of the student's diagnostic activities according to instructions, but with the admission of improvisation;
- assisting the student at each stage of diagnostic activities;
- fixation and analysis of all positive achievements;
- consolidation of student abilities by performing a system of multi-level tasks.

Stimulation strategy. The organization of the educational process is based on the adaptive management of studying and cognitive activity and the principle of stimulation. The teacher forms cognitive motives and a positive attitude towards diagnostic activities and thereby encourages the student to solve diagnostic problems in a sample. The strategy includes a receptive and instrumental model-prescriptions.

The recipe model-prescriptions has the characteristics described above.

The main features of the instrumental model-prescriptions are:

- formation of a positive attitude towards diagnostic activities;
- organization for students of the process of knowing the purpose of the diagnostic activity and its rules;
- building a model of diagnostic action;
- showing samples of the performed diagnostic action;
- implementation of the diagnostic action and careful verification of its compliance with the sample;
- adaptation to the specifics of the diagnostic activity;
- a system of multi-level tasks in the error-free implementation of the whole complex of diagnostic actions.

The Guide strategy is based on the local management of studying and cognitive activity and on the principle of leadership variability. The teacher manages the student's diagnostic activities,

which are already aimed at solving diagnostic problems in a modified situation. The strategy combines the implementation of three previously described model-prescriptions: receptive, instrumental, and relaxopedic, which is the basis for the application of cultural studies. The model-prescriptions described above does not change its meaningful characteristics and is used by the teacher depending on the specific didactic task.

Cultural model-prescription is implemented by the rules:

- providing students with the conditions for practical contact with any diagnostic phenomenon (work, phenomenon, process);
- discussion of the existing requirements involving his knowledge;
- determining the place of the diagnostic phenomenon in the history of culture;
- creating a model of a diagnostic phenomenon (work, phenomenon, process), which allows to understand its essence;
- organization of the problem analysis of the diagnostic phenomenon leading to its assessment;
- the organization of conditions for the use (application) of the diagnosed diagnostic phenomenon in practice (in the process of diagnostic activity);
- the formulation of practical and problematic conclusions concerning the diagnostic activity of students.

Cooperation strategy. Its essence is manifested in the indirect management of the teacher and is reflected in the principle of cooperation. Here the transition of the management of studying and cognitive activity from a monologue to a dialogical basis is carried out. The teacher concentrates the student on solving diagnostic problems in a non-standard situation or close to the practice. This strategy combines a research and dialogue model-prescription.

The research model-prescription involves:

- creation of a problem situation for students;
- formulation of a diagnostic query and the definition of the task;
- organization of an independent search for their solution;
- validation of diagnostic solutions;
- consolidating the knowledge gained about pedagogical diagnostics in practice;
- streamlining of new knowledge and skills obtained in the process of solving diagnostic problems;
- organization of the application of the acquired knowledge and skills in new situations.

The content of the dialogical model-prescription is:

- in presenting to students to discuss a diagnostic problem;
- in the actualization of previously obtained knowledge about pedagogical diagnostics;
- the inclusion of this knowledge in new contexts;
- in the presentation and argumentation of their point of view on the diagnostic problem;
- in criticism of opinions expressed;
- in the examination and self-diagnosis of diagnostic actions;
- in search of a convention to solve a diagnostic problem.



Co-creation strategy. The implementation of this strategy is determined by the reflexive type of management and the principles of self-management and co-creation. The strategy is aimed at expanding the possibilities of student self-realization in diagnostic activities, when he himself concentrates on the formulation of diagnostic problems and organizes the process of solving them. The strategy is presented by cultural and research models-prescriptions, which are described above, as well as innovative. In the listed combination, these models acquire a specific character, which contains the following elements:

- the creation for students of the situation of co-creation (self-creation), allowing them to come into contact with some diagnostic phenomenon (work, phenomenon, process);
- independent formulation of the problem;
- formulation of a hypothesis, based on the diagnostic aspect of studying the phenomenon;
- organization of an independent search for diagnostic tools and methods by which a solution to the problem is possible;
- the organization of situations that lead to the analysis and evaluation of the phenomenon under study (works, phenomena, process);
- simulation of situations that lead to the examination, as well as self-diagnosis of their own activities in the process of finding a solution;
- independent acquisition of knowledge about pedagogical diagnostics;
- streamlining and consolidating the knowledge gained in the process of applying them in new situations;
- organization of conditions for the creation of original diagnostic products;
- organization of conditions for the use (application) of the created diagnostic work in practice (in the process of diagnostic activity);
- formulation of prognostic conclusions on the solved problem.

Based on the characteristics of pedagogical strategies and the specifics of model-prescriptions, a system of multi-level tasks has been developed for the formation of diagnostic competence at each stage of the differential technique. The author's complex of diagnostic and training facilities with computer support determined the effective implementation of the differential technique. This system was implemented in the process of general pedagogical training of students: "propaedeutics", the study of basic disciplines of the pedagogical cycle (I – II courses), "school" teaching practice (II – IV courses), "creation" mastering special courses (undergraduates).

The complex contains ideal and material means, which in turn are diagnostic and / or educational and methodical.

The composition of the ideal tools include: pedagogical strategies for organizing the learning process, which are specified in the model-instructions; methodical maps of didactic procedures for the three stages of the differential technique; system of multi-level educational, research, creative tasks.

Material resources include: the program and methodological support of the special course; questionnaires, diagnostic cards, tests for diagnosis and self-diagnosis; check questions; diagnostic instrumentation system diagnostics of educational opportunities of students; scenarios of business

games “Praxeologist”, “Expert advice”; textbook “Formation of diagnostic competence among students: propaedeutics, school, creation” (Artemenok, 2007); anthology “Diagnosis of upbringing of schoolchildren” and “Diagnosis of student learning”.

As computer support developed: complexes “Diagnostics of learning capabilities” and “Diagnost”; a set of electronic presentations, electronic teaching textbook “Pedagogical diagnosis”.

To ensure the learning process with operational diagnostic information, we developed a “Methods of systemic diagnostics of learning capabilities”. Also created its computerized version. The computer complex “Diagnostics of learning capabilities” was developed in accordance with the logic of the organization of the learning process based on system pedagogical diagnostics. It implements (optimizes) the first four steps of the heuristic algorithmic prescription, which is presented above.

The computer complex consists of two subsystems: the first - “Respondent” - involves the subject's work in the diagnostic mode; the second - “Administrator” - provides opportunities: create new test items, adjust existing ones; view the results for the entire sample; statistically process the data obtained.

The toolkit of the computer complex was developed on the basis of the approach according to which a completely new diagnostic tool (questionnaire, test, map) is constructed. Therefore, the specifics of the diagnostic task, namely the system diagnostics of the “learning capabilities” parameter, are taken into account as much as possible. This task is solved by the targeted selection of test stimuli, the formulation of individual questions and tasks.

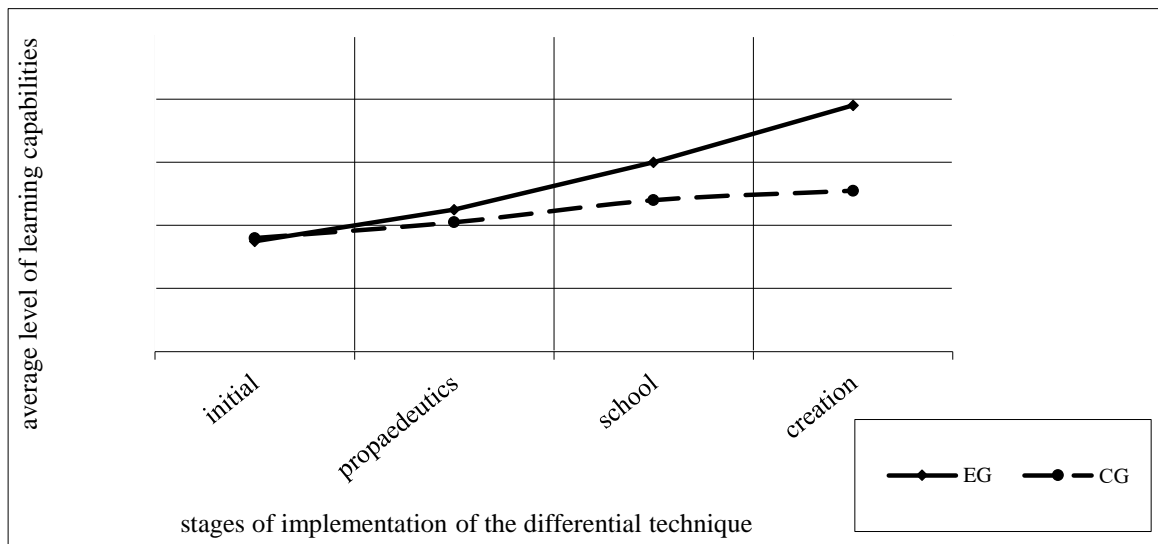
The complex “Diagnostics of learning capabilities” consists of two modules: complex and express diagnostics. Information obtained in both modules is summarized. The diagnosed is studied not only with the help of methods based on self-assessments (test “Pupil”), but also on the basis of expert assessments - subject teachers (test “Teacher”), psychologist (test “Psychologist”) and medical worker (test “health worker”). This allows you to collect data of three types: L-, T-, Q-data, which multidimensionally measure the parameter “learning capabilities”.

Generalized data is accumulated as indices in the matrix-accumulator. It for the diagnostician is presented in the form of “Final diagnostic cards” for the two modules separately. The final information in the diagnostic maps contains: the value of the cumulative index of training opportunities, the quantitative assessment of each indicator, the degree of confidence of the subject's self-assessments (“lie scale”), the respondent's typological group, and the recommended strategy for organizing the learning process. On the basis of the final list by group (class), you can analyze not only each student, but also evaluate the characteristics of the diagnosed group as a whole, see the proportion of recommended strategies for organizing the learning process. In accordance with these data, a computer program selects an adequate pedagogical strategy for organizing the student's learning process, based on its belonging to one or another typological group. The pedagogical strategy of teaching each student on the basis of diagnostic data acts as an invariant of the general context of the organization of the learning process.

## 2.2 The results of the pedagogical experiment

The effectiveness of the differential technique was determined on the basis of measuring the level of “learning capabilities” of students who participated in the experiment. For this, the control group (CG) and the experimental group (EG) were compared. In the EG a differential technique was carried out. During the 5 years of study, these students mastered the content of the diagnostic activity of the teacher and formed the components of diagnostic competence (cognitive-search, model-design, managerial-communicative and assessment-orientational). The following features are defined.

The component “learning capabilities” has the greatest effect on the success of the process of forming diagnostic competence (this tendency was identified even at the stage of identifying typological groups). This data confirms the stable dynamics of development of training opportunities in the EG, in contrast to the CG (**Fig. 1**).



**Fig. 1.** Dynamics of “learning capabilities” in experimental and control groups of students

In the process of implementing the differential technique, the value of the “learning capabilities” parameter in the EG of students increased from 0.34 to 0.78. In the CG students, the value of the parameter has changed from 0.36 to 0.51.

In summary **table 3** presents the results of computer diagnostics of educational opportunities of students. They were taken into account in the EG during differentiation at various stages of the experiment. The CG data are given for comparison in order to reveal the dynamics of changes caused by the use of a differential technique.

Table 3. Results of computer diagnostics of learning capabilities of students at various stages of the differential technique

Typological group	Stages of implementation of the technique							
	initial		propaedeutics		school		creation	
	percentage, %							
	CG	EG	CG	EG	CG	EG	CG	EG
weak	33,0	25,5	29,6	21,8	17,5	11,9	11,0	0,9
medium-weak	38,4	43,6	38,5	43,6	26,4	20,9	22,0	9,1
average	19,8	23,6	23,1	25,5	38,4	36,4	48,4	23,6
medium strong	7,7	5,5	8,8	6,4	12,1	22,7	12,1	42,7
strong	1,1	1,8	1,1	2,7	5,5	9,1	6,7	23,6

The ratio of typological groups at various stages of the implementation of the differential methods in the EG and the CG, the analysis of compiled cross-tables and diagrams, revealed the dynamics of growth in the level of students' learning capabilities and their influence on the level of diagnostic competence at all stages of the experiment. The greatest dynamics of the development of the “learning capabilities” parameter was revealed in the EG: at the stage of propaedeutics, it was 0.11, at the school stage - 0.15, at the creation stage - 0.18. These data indicate the relationship between the development of learning capabilities for students and components of diagnostic competence. It also allows to state that the selected strategies for organizing the process of forming diagnostic competence were adequate to the goals of the differential technique.

The increase in “learning capabilities” is weakly expressed in the CG. If we compare the observations with the corresponding periods of the implementation of the differential technique, then the dynamics are as follows: the stage of propedeutics is 0.05; schools - 0.07; creation - 0.03.

The transition from one typological group to a higher one was observed during the period of implementation of the methods in the EG among 70.9% of students. At the same time, with traditional training in the CG, such a transition was detected only in 38.7%.

Within the “learning capabilities” parameter, the strongest correlation is found between the variables “degree of training” and “mastery of intellectual skills” (0.5), as well as “attitude to study” and “mastering intellectual skills” (0.5).

Among the components of diagnostic competence, the strongest correlation was found between “cognitive-search” and “model-design” (0.7), as well as “managerial-communicative” and “assessment-orientational” (0.8).

The most significant correlation between the objective and subjective components was found between the “assessment-orientational” component and the variable “degree of training” (0.5) and the “model-design” component and the variable “degree of training” (0.5).

As a result of factor analysis, the author of the study revealed that:

- at the “propedeutic” stage, 4 factors have the strongest influence on the level of diagnostic competence (arranged as they are affected):

F1 - physical performance and attitude to study;

F2 - cognitive independence and degree of training;

F3 - mastery of intellectual skills;

F4 - cognitive-search component;

- at the “school” stage, 2 factors exert the strongest influence on the level of diagnostic competence:

F1 - model-design and assessment-orientational components;

F2 - cognitive independence and attitude to study;

- at the “creation” stage, 3 factors already have the strongest influence on the level of diagnostic competence:

F1 - degree of training, physical performance and attitude to study;

F2 - degree of training and mastery of intellectual skills;

F3 - cognitive independence.

In the course of the experiment, it was proved that the level and dynamics of the development of “learning capabilities” affect the degree of formation of the components of diagnostic competence. It was revealed that there is a close relationship between the variables of “learning capabilities” and the components of diagnostic competence among students in the experimental group. At all stages of general pedagogical training, the variables “attitude to study” and “cognitive independence” have a significant effect. At the “creation” stage, the factors consisting of the variables of the parameter “learning capabilities” dominate, that is, the individual characteristics of the subject's diagnostic activity significantly affect.

### **3 Conclusion**

Differential technique has shown its effectiveness in the process of teaching pupils and students. During the period of implementation of the differential methods, the average level of development of learning capabilities in the EG increased from 0.34 to 0.78, which amounted to an increase of 2.3 times. While in the CG, the parameter has changed from 0.36 to 0.51 (an increase of 1.4 times).

The complex of diagnostic and training facilities with computer support implements the goal, the tasks and provides the stages for the implementation of the differential technique in the organization of the student learning process. In the course of the pedagogical experiment, the complex confirmed its effectiveness, since: it provides operational system diagnostics and feedback; allows for the differentiation of students; contributes to the individualization of the learning process; contributes to the choice of an adequate strategy for organizing the learning process; optimizes the studying and cognitive activity of students.

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