LOOK ACADEMIC PUBLISHERS
OPEN ACCESS

INTERNATIONAL JOURNAL OF ENVIRONMENTAL & SCIENCE EDUCATION
2016, VOL. 11, NO. 17, 10445-10454

Psycho-Pedagogical Measuring Bases of Educational Competences of Students

Kulush K. Kenzhegaliev[a], Aisulu A. Shayakhmetova[a], Zhamila A. Zulkarnayeva[a], Balzhan K. Iksatova[a] and Bakytgul A. Shonova[a]

[a]Kokshetau State University named after Sh. Ualikhanov, Kokshetau, KAZAKHSTAN

ABSTRACT

The relevance of the research problem is conditioned by the weak development of measurement, assessment of educational competences at an operational level, at the level of actions, by insufficient applications of psycho-pedagogical theories and methods of mathematical statistics. The aim of the work is to develop through teaching experiments the content and structure of the educational competencies at the operational level and actions to measure accurately the educational competencies of students. Research methods: questionnaires, ranking, self-evaluation method – rating, content analysis of educational material, modeling of the content and structure of educational competences in the context of skills for a specific section of the physics course, statistical processing of the data. The result of the research is the realization of the ideas of measurement, assessment of educational competences by creating a model of the content and structure of abilities and skills for a specific section of the course at the level of operations, actions. Measurement of abilities and skills at the level of operations and actions is a more accurate measurement of educational competences in comparison with the existing methods. The proposed model of educational competences' structure allows one to see the content of the material at the level of actions, as the knowledge is solid when it is evidenced by the execution of actions (solving of equations, tasks, etc.).

KEYWORDS
Measurement, educational competences, the model, theory of gradual formation of actions, psychological and pedagogical foundations

ARTICLE HISTORY
Received 18 July 2016
Revised 11 September 2016
Accepted 9 October 2016

Introduction

The research problem

The improvement of the content of education presupposes the improvement of the methods to measure learning outcomes. Learning and teaching results are the educational competences of students, and the result of complex mental processes in the brain which are implicit, hidden and latent by nature.

CORRESPONDENCE Kulush K. Kenzhegaliev ✉ kulushk@mail.ru

Worldwide, the cornerstone of the Bologna process is the result of education, and each state in line with the Bologna process should develop and improve the national monitoring system of learning outcomes of students (Baidenko, 2004; Shitov & Kalney, 2000). It seems to us that, all countries strive to make the same matrix of education, and all of them are oriented on the developed countries. But the methods of training and evaluation are different. Therefore, the problem of improving the assessment of learning outcomes is the most complex pedagogical, didactic task (Avanesov, 2004; Glazunov, 2003). It should be admitted that the psychological works of foreign, Soviet psychologists and their methodology on this question is still to be examined (Engels, 1987; Herbert, 2007).

Like all matter consists of atoms and molecules, the building consists of bricks so learning activity consists of separate abilities and skills, which are implemented at an operational level. Modern physics further develops through the study of its minutest structural elements, just as the problems of qualitative training will be solved at the level of the formation of the operations learning activities. Training operations contribute to the implementation of training actions, which is the essence of abilities and skills. Problems of quality of training are not conditioned by the formation of abilities and skills at the operation level. It is appropriate to say about the relationship of consciousness and educational practice. In the minds rolled-up practical actions in the form of heard and completed activities' images are generated and the training activity acts as a training process (Leont'ev, 2005). The structure of the educational process as the activity includes training activities as a form of interaction "student - teacher", "student-book", "student – problem solving, "student – lab activity". These interactions are carried out at the level of actions and operations. Training activities of the teacher form "rolled up actions": images, concepts, formulas, phenomena, etc. in the mind of the pupil (Lord & Novick, 1968)

Consciousness is successfully formed, if a teacher of any discipline deals with the subject at the operation level. At the operation level the formation of any scientific concept occurs, according to the methods of teaching each discipline. For example, 345x345=149025 contains "action to perform multiplication"- this only action consists of 23 oral mental operations. The quality of any knowledge is fully correlated with the full implementation of the educational operations. Our survey shows that many teachers of mathematics, physics can't solve some tasks. Many of the errors are made by pupils at an operational level. Knowledge and implementation of actions at an operational level is associated with higher mental function of the brain (Vygotsky, 1984). In the development of training psyche the leading role belongs to the methods of teaching, no wonder this branch of pedagogy by J.A. Comenius (1989) is called "The great didactics", improving teaching methods we improve the content of education, just as in engineering, and in all Sciences. About the methodology in astronomy Archimedes briefly put it in this way: "Give me a fulcrum and I will lift the Earth" and it is theoretically possible, but practically impossible. Unfortunately we have to admit that the methods of teaching in universities is minimized, which resulted in negative increase in qualitative training for the professional competence of teachers.

Important thing in the learning process is the formation of the most common, universal abilities and skills of the natural Sciences. These abilities and skills are formed at the level of operational actions, i.e. operations. We believe that the development of abilities and skills in physics in secondary school (in any subject) is based on the theory of activity (Leont'ev, 2005), the theory of the gradual formations of mental actions (Galperin & Talyzina, 1989), on the properties of the higher mental functions of the brain (Vygotsky, 1984). As a result, educational competences are generated on the subject.

In connection with the unified national testing (UNT) the formation of abilities and skills was not paid enough attention, resulting in decreased quality of knowledge, abilities and skills of school graduates. Logical cycle, "the content of education-methodology of formation of knowledge, abilities and skills-the result of training and education" was broken because from the system the "methodology of formation of knowledge, abilities and skills" was excluded. It is not just a school problem, but the problem of professional competence of teachers. In senior grades of the school the lessons are devoted to learning tests, students just are coached on the ready answers that is unnatural to the theories of higher mental functions of the brain (Podlasiy, 1990).

Modern education requires a new comprehension of the theory and the methodology of evaluating the academic competences of students which would contribute to the creation of educational abilities and skills.

Materials and methods

Research methods

In the process of investigating this problem, the author relied on many years of personal experience of teaching in secondary schools of Kokshetau, Kokshetau state pedagogical Institute, later the University named after Shokan Ualikhanov. The following research methods were used: theoretical analysis of the problem from the sources and its synthesis; the study, analysis and generalization of advanced pedagogical experience of teachers; conducting of questionnaires among the teachers on the research problem; study of the curricula on physics in secondary school, instructional materials, conducting of laboratory work on identification of level of formation of educational competence in "Electrodynamics". Pedagogical experiment was conducted: ascertaining (pedagogical observation, the testing of the level of abilities and skills in physics, identifying of the content and structure of abilities and skills, ranking of the structure of abilities and skills; forming pedagogical experiment, the development of short-term laboratory work, conducting of formative laboratory work. For the validation of conducted training experiments the method of mathematical statistics was used: the coefficient of completeness of implementation of the actions (Usova, 1980), testing of statistical hypotheses (Grabar & Krasnyanskaya, 1977), the significance coefficient, the criterion of "Chi" - square test (Melnik, 1983).

Experimental base of the research

The pedagogical experiment was held in secondary school № 1, school № 2, school № 5 of the city of Kokshetau, in the school № 25, school № 45 in Almaty, in Chkalov secondary school, Kokshetau region. Approbation of results of

research was conducted at qualification's improvement courses of teachers of physics at the Regional Institute of qualifications' improvement of teachers.

The stages of the research

The study of the problem of formation of abilities and skills was conducted in three stages:

In the first stage, the existence of a problem based on personal teaching experience of physics at school was identified, then the state of the problem from the theoretical sources was studied, numerous interpretations of the concept "educational competences", and the full range of abilities and skills for all mathematics and science disciplines were reviewed and analyzed. The hierarchy of the concepts "knowledge", "abilities" and the skills" were studied in the psychological works of the classics of the psychology and scientists - educators. The results of the first phase of the study allowed receiving of a comprehensive overview of the research problem; that is, the abstract view of the research problem was received. The absence of a scientific definition of "educational competence" in application to the subject matter was revealed.

In the second phase an analysis of the curriculum for forming of abilities and skills was carried out, the content and structure of educational competence for the section "Electrodynamics" was developed by the survey of teachers of physics, by analyzing the content of the section, the list of laboratory and practical material for the formation of abilities and skills was analyzed, diagnostic-ascertaining experiment of the level of formation of the identified structures of abilities and skills was conducted. Control and measuring toolkit, based on mathematical, statistical methods was developed.

In the third phase a formative experiment was conducted for the development of educational competences, the results of formation of skills were determined by the correct methods of mathematical statistics. The scientific definition of "educational competences" was given. The content and structure of educational competences according to the section "Electrodynamics" were proposed. Topics of similar studies in other parts of physics courses at school and university on the developed research methodology were suggested.

Results

The structure of the model content

A modern secondary school is characterized by the combination of high scientific level of teaching physics with familiarization of students with the fundamentals of modern engineering and technology in the industrially developed country and in the world. The conservatism of the content and methods of teaching are determined by the peculiarity of the education sector. Therefore, the problem of education whatever it was the old one it was not exhausted itself in the content of education in the modern era (Atutov, 1976, 1978). Then why did the graduates of the real schools of Russia before the revolution become engineers in the true sense of the word and the modern graduates of technical universities do not become. The content of school course in physics is lagging behind in its content from the level of development of scientific-technical progress. The filling of the physics course with modern content do not contradict to our method of formation of abilities and skills. The formation of abilities and skills requires further systematization of educational

material and bringing this content to the level of development of science in the world (Razumovsky, 1977).

In the development of educational competences the leading place belongs to the content: diagrams, drawings, concepts, graphic material.

Table 1. The content of educational material on the topics in section "Electrodynamics".

№	Educational material	Electrostatics	Constant el. current	El.current in a variety of environments	Magnetic field	Electromagnetic induction	Total:	in %
1	Schematic drawings of the devices	25	7	15	7	3	57	29,8
2	Drawings of educational visual aids	12	11	2	13	9	47	24,7
3	Technical devices	1	9	17	0	0	18	9,4
4	principal scheme and graphics	17	17	11	11	13	69	36,1
	Totally on topics	55	35	45	31	25	191	100

Table 1 shows that the illustrative material is only 9.4 %. These 9.4 % represent the subject "electric current in various environments" and other topics in the section "Electrodynamics" such illustrations and schemes do not have.

Important one for our study is the content and structure of educational competences in the context of abilities and skills on this section. During the study, we interviewed 43 teachers with many years of experience in teaching physics. Teachers were asked to identify those abilities and skills that would facilitate successful implementation of laboratory-practical works, and therefore would contribute to competences' formation. The results of the survey were ranked and the first chosen four according to their coefficient's significance were sele

Table 2. Components of educational competences

№	Evaluationa of Skills	Coefficient of the significance
1	Experimental abilities and skills	7,83
2	computational abilities and skills	6,97
3	abilities and skills of electro-measurement	6,58
4	Graphic abilities and skills	6,53

Other abilities and skills in view of low significance in this table are not included. According to expert teachers, the formation of the indicated (Table 2)

abilities and skills are sufficient for successful implementation of laboratory and practical works. The optimal coefficient of significance is 6,50 therefore, the remaining five types of abilities and skills in this table are not included. The results of the survey were processed by a method of ranking "Matrix of ranks" and frequency method "Matrix of frequencies" (Kuteinikov, 2008)

Table 3. The matrix of ranks based on the survey of 43 teachers

№	A	B	C	D	E	F	G	H	I	№	A	B	C	D	E	F	G	H	I
3	2	5	4	9	8	4	3	5	2	**23**	3	4	4	4	5	5	6	3	4
4	1	1	3	6	6	3	1	1	4	**24**	2	1	3	2	2	1	3	1	2
5	7	3	4	9	8	5	6	2	1	**25**	2	2	4	8	6	1	2	2	3
6	3	2	5	7	6	6	4	3	4	**26**	1	1	3	7	9	2	2	1	4
7	2	2	3	9	3	3	2	4	3	**27**	1	1	4	5	9	2	2	1	7
8	3	1	4	9	8	1	6	2	2	**28**	2	2	3	4	6	2	1	1	4
9	2	3	4	4	3	5	1	1	1	**29**	1	2	3	6	7	2	3	1	4
10	2	1	4	5	8	3	2	1	2	**30**	1	1	1	4	2	2	2	1	3
11	1	1	3	7	6	4	4	2	5	**31**	2	2	8	8	9	2	2	1	3
12	1	2	3	2	8	7	5	7	8	**32**	1	1	4	9	8	2	4	1	7
13	1	1	3	6	6	2	2	1	3	**33**	1	1	3	6	7	1	2	3	3
14	3	2	4	1	1	5	7	6	8	**34**	1	1	2	6	3	2	2	1	3
15	7	2	6	3	4	5	9	1	8	**35**	3	2	2	3	2	4	1	1	1
16	1	1	2	5	4	1	2	1	2	**36**	1	1	2	1	1	2	2	1	1
17	3	4	4	2	9	2	1	1	2	**37**	2	3	2	6	4	1	2	1	7
18	4	2	5	3	9	6	7	8	1	**38**	2	4	3	6	8	4	3	2	3
19	2	1	3	3	5	1	1	1	3	**39**	1	1	3	9	8	4	3	2	5
20	2	2	4	6	7	1	3	1	5	**40**	1	1	1	5	2	2	1	1	3
21	1	2	9	4	3	6	5	8	7	**41**	2	1	3	9	8	2	2	2	8
22	1	2	8	5	3	6	4	5	2	**42**	4	2	3	9	9	3	2	2	7
										43	3	1	6	7	8	2	1	2	7

This matrix is used for making of matrix of frequencies. Consider the rule of drawing up this matrix on the example of the column "A". By counting it is established that the rank 1 occurs 18 times, rank 2 is found 13 times, rank 3 occurs 7 times, 4th rank is found 2 times, rank 5 is found 1 time, etc. grade 9 occurs 0 times. These frequencies are captured in the matrix of the frequencies in each row of the column of the same name.

Table 4. The matrix of frequencies

№	C_i	A	B	C	D	E	F	G	H	I
1.9	9	18	20	3	2	2	9	8	23	6
2.8	7	13	15	5	3	4	14	16	10	7
3.7	7	7	4	15	4	5	4	6	3	10
4.6	6	2	3	13	6	4	5	4	1	6
5.5	6	1	1	2	6	2	6	2	2	3
6.4	6	0	0	2	6	3	4	4	1	0
7.3	5	2	0	0	6	3	1	2	1	6
8.2	5	0	0	2	2	11	0	0	2	4
9.1	4	0	0	1	8	6	1	1	0	1
		43	43	43	43	43	43	43	43	43

Let's compute the value of each object according to the formula of significance: $R_i = \frac{1}{N}\sum c_i f_{ij}$, where N- the number of respondents, f_{ij} – frequency rank, c_i – the numerical value of the rank in the normal scale $\sum c_i f_{ij}$ – the sum of the products of each element on the value of the ranks in the normal scale.

This method allowed us correctly to allocate the structure of abilities and skills on the level of activity (Leont'ev, 2005).

Results of questioning of pupils in order to identify their attitude to the formed abilities and skills by self-assessment gave the following results:

Table 5. Results of questioning of students

№	evaluated abilities and skills	Number of students	amount of points	average point
1	Abilities and skills of work with reference books, tables	425	1502	3,53
2	Measuring skills	425	1489	3,50
3	Ability and skills to observe	425	1422	3,34
4	Graphic abilities and skills	425	1385	3,25
5	Ability to plan and organize learning activities	425	1373	3,23
6	Computational abilities and skills	425	1356	3,19
7	Experimental abilities and skills	425	1307	3,07
8	Research abilities and skills	425	1241	2,92
9	Design abilities and skills	425	941	2,21

When developing the questionnaires for the students the aim was to find out the degree of possessing by those or other abilities and skills, how they evaluate the already formed abilities and skills. Here a special case of rating was used - the self-assessment. The obtained data were compared and analyzed with the results of the survey of teachers. The results of the questionnaire, analysis of curricula, content of laboratory works, as well as the study of learning activities of students allowed identifying of the structure of polytechnic abilities and skills. In figure 1 the structure of the Polytechnic abilities and skills in the context of activity, practical actions and at operation level is given. It is the operational level of actions that takes place on the level of mental operations that is internal interiorization and which at the level of practical actions moves into outer actions in the form of external interiorization (Kovalev & Radzikhovsky, 1985).

Discussion and Conclusion

Forming of learning competencies at the level of abilities and skills, at the operational level is the most effective when carrying out laboratory works, explanations of new material, during homework, during testing. The production of any product, installing is carried out at an operational level. Even in genetics, robotics, the process of control occurs successfully if the entire process at an operational level is prepared thoroughly. From this point of view, the monitoring of training, education, upbringing will be effective if the operational level of its execution is thoroughly prepared (Khutorskoy, 2003).

The student progress in mastering the skills and abilities is recorded in a special table. Actions aimed at development of abilities and skills in the proposed method are significantly different from existing teaching methods. Formation of abilities and skills take place without trial and error by pre-defined landmarks that ensure a correct and conscious implementation of each operation of the generalized abilities and skills of a generalized nature. Dedicated in the research process the structure of learning competencies fulfills

the role of an indicative framework of actions (Galperin, 1998). The proposed structure is a model of learning competences in electrodynamics.

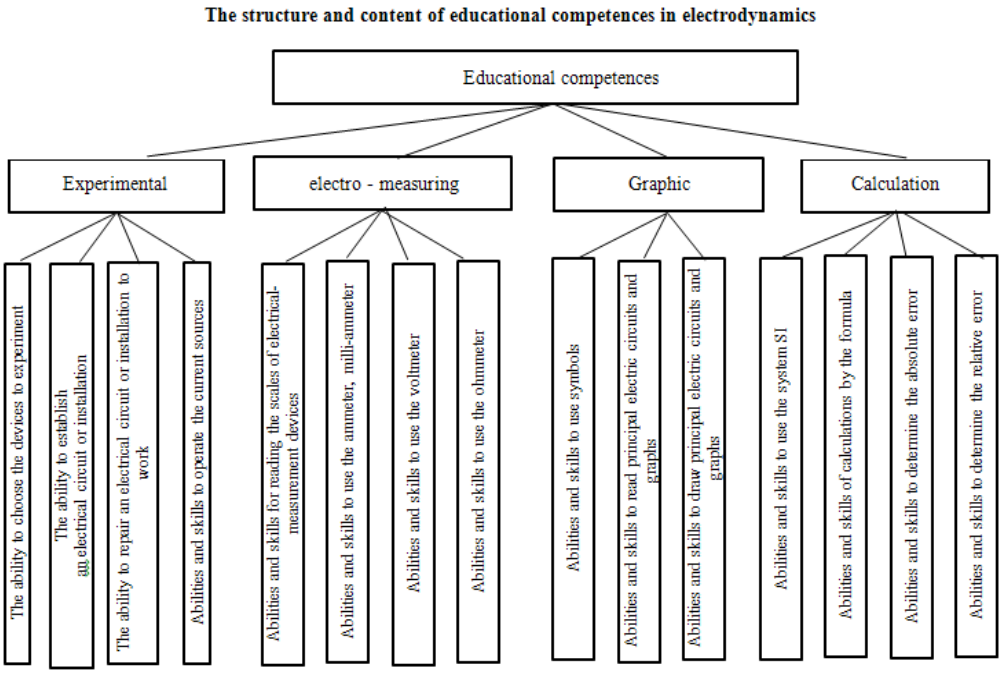

Figure 1. The structure and content of educational competences in electrodynamics.

To form the educational competencies short-term laboratory works are developed:

Studying the structure and principle of operation of an ohmmeter or avometr. The offered short-term laboratory works are designed to perform the following operations:

— Familiarization with the scale of avometr in various modes of operation.
— Determination of the division value at different modes of operation.
— Familiarization with the bands of switching modes.
— Setting of the arrow of the detent at zero, pre-closing the circuit.

1. Laboratory work: Measurement of resistance by avometr.

— Calculate the total resistance according to the passport of the device.

— Measure the resistance by avometr separately, then the resistance of all resistances.(sequential, parallel connection).

— Compare results 1 and 2 items.

— Determine the absolute error of measurement.
— Determine relative error of measurement.

2. Laboratory work: Connection of the elements in the battery and measuring of the voltage and current at the parts of the circuit.

— Assemble the electric circuit.
— Record the readings of the ammeter and voltmeter.

— Assemble the same electric circuit, only the elements connect in parallel.

— Record the reading of ammeter and voltmeter.

— Make a conclusion about how the readings of ammeter and voltmeter will be changed in sequential and parallel connections of elements in the battery.

During the forming pedagogical experiment were tested the adequacy of identified structure of abilities and skills, the logical continuity of the relations of these abilities and skills in a staged method of implementations (Halperin, 2008).

The possibility of a reasonable increase in the number of short-term laboratory works with electrical devices was investigated. It is determined that there are reserves of time for introduction in educational process of such works in the individual term to form and validate the abilities and skills. It turned out that when targeted forming of abilities and skills in the experimental classes, the level of development is higher than in the control classes, and more durable knowledge and skills can be formed in case, if these issues are devoted due attention in other lessons of natural-science cycle.

The result of this experiment is the conclusion about the necessity of a well-conceived system of teaching methods based on short-term laboratory works of modular type which teachers could use for the formation of generalized abilities and skills, which is the basis of educational competencies (Lerner, 1999).

On the basis of the experimental schools teaching-forming experiments were conducted, the structure of the educational competencies was determined, the level of development of abilities and skills was measured, methodological validity of conducting of short-term laboratory works was tested, developed to form educational competencies at the level of operations whose purpose was the continuous formation of generalized abilities and skills of competence character.

Card with a different scale of physical devices are designed in which to determine the readings of the devices one needs to perform three to five mental operations. That is a solid formation of mental operations becomes practical actions, which in turn makes the base of learning activities.

Therefore, the students of the experimental classes were faced up the task of mastering experimental, electrical-measurement, graphic and calculation abilities and skills of competence character, as show didactic means, which were developed together with teachers.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Kulush K. Kenzhegaliev - PhD, Associate Professor of the Department of Pedagogy, Psychology and Social Work, Kokshetau State University named after Sh. Ualikhanov, Kokshetau, Kazakhstan.

Aisulu A. Shayakhmetova - PhD, Associate Professor, Head of the Department of Social and age Pedagogy, Kokshetau State University named after Sh. Ualikhanov, Kokshetau, Kazakhstan.

Zhamila A. Zulkarnayeva – M.S., Senior Lecturer of the Department of Social and age Pedagogy, Kokshetau State University named after Sh. Ualikhanov, Kokshetau, Kazakhstan.

Balzhan K. Iksatova - M.S., Senior Lecturer of the Department of Social and age Pedagogy, Kokshetau State University named after Sh. Ualikhanov, Kokshetau, Kazakhstan.

Bakytgul A. Shonova - M.S., Senior Lecturer of the Department of Social and age Pedagogy, Kokshetau State University named after Sh. Ualikhanov, Kokshetau, Kazakhstan.

References

Atutov, P.R. (1976). *The Polytechnical principle in teaching children*. Moscow: Pedagogika,

Atutov, P.R. (1978). *The formation of students polytechnic knowledge and skills in the process of learning basic Sciences*. Moscow: Pedagogika

Avanesov, V.S. (2004). Fundamentals of theories of pedagogical measurements. *Jour. Pedagogical dimension, 1,* 5-10

Baidenko, V.I. (2004). *Bologna process. A course of lectures*. Moscow: "Logos".

Comenius, J.A. (1989). *Pedagogical legacy*. Moscow: Pedagogika,

Engels, F. (1987). *Dialectics of nature. Ed-tion "Political literature"*. Moscow: Logos.

Galperin, P.Y. (1998). *Psychology as an objective science. M.: Publishing house "Institute of practical psychology"*. Voronezh: "MODEK".

Galperin, P.Ya. & Talyzina, N.F. (1980). The theory of gradual formation of mental actions. Electronic resource". *Wikipedia – the free encyclopedia*. Moscow: Science

Glazunov, A.T. (2003). *Educational research: content, organization and processing of the results*. Moscow: Publishing center APE.

Grabar, M.I. & Krasnyanskaya, K.A. (1977). *The application of mathematical statistics in educational research. Non-parametric methods*. Moscow: "Pedagogika", 136 p.

Herbert, I.F. (2007). *Psychology*. St.Petersburg: "Territory of the future".

Khutorskoy, A.V. (2003). Key competences as a component of personality-oriented education. *Journal People's education, 2*, 17-22.

Kovalev, G.A. & Radzikhovsky, L.A. (1985). Communication and the problem of interiorization. *Questions of psychology, 1*, 110-120.

Kuteinikov, A.N. (2008). *Mathematical methods in psychology*. St.Petersburg: Speech.

Leont'ev, A.N. (2005). *Activity. Consciousness. Personality*. Moscow: Meaning.

Lerner, P.S. (1999). Generic skills - action as a system forming technological component of self-determination of growing personality. *Theses of the report*. Moscow: Science.

Lord, F.M. & Novick, M. (1968). *Statistical Theories of Mental Test Scores*. New York.

Melnik, M. (1983). *Fundamentals of applied statistics*. Transl. from English. Moscow: Energoatomizdat.

Podlasiy, I.P. (1990). Let us judge the computer. *National education, 8*, 49-54

Razumovsky, V.G. (1977). The formation of abilities and skills, development of creative abilities. *In the book Improving the teaching of physics in secondary school*. Moscow: Science.

Shitov, S.E. & Kalney, V.A. (2000). *School: monitoring of education*. Moscow: Logos.

Usova, A.V. (1980). On the criteria and levels of formation of cognitive abilities and skills. *Soviet pedagogy, 12,* 45-49.

Vygotsky, L.S. (1984). *The history of development of higher mental functions*. Moscow: Pedagogy.