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Natalya A. Nikitenko

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Natalya A. Nikitenko

Mailing Address:
14, Belorusskaya St.,
Togliatti,
Russia, 445020
Phone: **(8482) 44-91-74**
E-mail:
vektornaukitgu@yandex.ru

Website:
https://vektornaukipedagogika.ru

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ПСИХОЛОГИЧЕСКИЕ НАУКИ

PEDAGOGY

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The content of the term of individualization of learning in the context of the history of the development of the idea of individualization in education

Sergey V. Pavlov, postgraduate student
F.M. Dostoevskiy Russian Christian Academy of Humanities, St. Petersburg (Russia)

E-mail: pvlsergey@mail.ru ORCID: https://orcid.org/0009-0008-6378-2480

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Abstract: In the theory of pedagogy, an uncertainty associated with the content of the term of individualization of education has existed for a long time. Various authors define and use the term of individualization in a variety of senses, often having not nuanced, but fundamental differences. The situation is partly aggravated by the fact that the term is not directly defined in the legislation of the Russian Federation, and the term definition in the Russian Pedagogical Encyclopedia practically borrowed from the Soviet Pedagogical Encyclopedia is incomplete from a historical and methodological point of view. In this paper, by analyzing the stages of development of the idea of individualization of education, the author formulates the content of the term of individualization to solve the problem of existing discrepancies in the definition of this term and the content of individualization in education. The difference in the content of the term of an individual approach and individualization of education is highlighted. The author considers the history of the development of the idea of individualization by the method of historical periodization using the historical-genetic approach, which allows considering the trend towards individualization in education as a dialectical alternative to the traditional teaching system from the moment of the birth of the concept of an individual approach in learning. The creation of the first individualized teaching method by E. Parkhurst, the Dalton plan, is presented as the result of the development of the idea of individualization in education. Obviously, the results obtained do not create a new understanding of the term of individualization in education, but only substantiate scientifically the use of this term with a certain methodological content, which is already used by some educators. The content of the term of individualization in education proposed in the paper allows excluding the existing duplication and confusion of concepts in this area.

Keywords: individualization of education; individualization of learning; individual approach; personalization of learning; personification of learning; Dalton plan; Parkhurst.

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INTRODUCTION

In modern pedagogy, a problem of defining the content of the term of individualization of learning exists, despite the fact that this term appeared more than a hundred years ago. The American educator E. Parkhurst was one of the first who used this term in relation to the teaching method she developed, which was called the Dalton plan. The method is based on the principles of freedom, independence and cooperation of students. The essence of the method is in independent work on educational material in organized laboratory classes under the supervision of a teacher, according to an individual curriculum compiled by the student himself, with a general curriculum divided into weekly and monthly parts for monitoring implementation, and the rejection of the class-and-lesson system of teaching. In other words, the transfer of "ready-to-use experience" by the teacher is replaced by the acquisition of "personal experience" by students, and work according to a curriculum "oriented towards the average student" formed by the teacher is replaced by the implementation of a plan that, albeit spontaneously, is formed by the student himself. The main principle that distinguishes the Dalton plan from the traditional system of education is the adaptation of the parameters of education (pace, load, alternation of subjects) by the student "for himself".

However, the author herself, being the founder of the world's first systematically complete method of individualization, did not give a definition of the term itself. Perhaps, therefore, in the pedagogical literature regarding the term of individualization, many versions and different interpretations have appeared which still exist today. Therefore, theoretical studies on the issue of individualization begin with large introductory parts describing the content of this term in the understanding of the author and various educationists. The concepts of individual learning, individual approach and individualization were supplemented by the terms of personalization and/or personification of learning. In addition to the fact that in theoretical works, we see a variety of definitions characterized by different shades of meaning, it is not so rare we observe a mixture or duplication of concepts. In our opinion, the ambiguity of concepts both confuses the development of theoretical thought and

hinders correct and meaningful pedagogical practice, because if even in scientific papers, there is no single point of view, then can we hope for a correct understanding of the essence of concepts by teachers "on the ground"?

Analyzing the technologies of individualized learning, the authors [1] report that "the technology of individualization of learning is built directly on an individual approach, which can be defined as the organization of the educational process based on considering the characteristics of students" [1, p. 209]. Almost the same interpretation is used in the study [2]: "taking into account the individual characteristics of students in the learning process" [2, p. 21] and in the work [3]. It is evident that the authors practically equate the concepts of an individual approach and individualization. However, it is wrong to blame them for this, because they repeat this point of view from the Russian Pedagogical Encyclopedia: "Individualization of learning, organization of the educational process, taking into account the individual characteristics of students"[1], which, in turn, almost repeats the definition of individualization from the Soviet Pedagogical Encyclopedia of 1965. It is not surprising that the majority of Soviet, and later Russian, educationists perceived individualization as an individual approach, sometimes even without mentioning collective learning, although it is difficult to explain why the theoretical apparatus of science needs a second term denoting the same thing.

Another confusion of concepts sometimes occurs between differentiation and individualization of learning [4], which ideologically goes back to the point of view of I.M. Osmolovskaya: "Individualization is an extreme case of differentiation" [5, p. 7] defining the differences between approaches only as quantitative.

Since individualization of learning in the interpretation of the Soviet, and later Russian, encyclopedia was reduced to an individual approach, a separate concept was needed to describe the active role of the student in the process of forming learning parameters. Zh.A. Abalyan, considering the genesis of the term of personalization in education, points to its coming from psychology, as well as to the use of the term of personalization of education by A.V. Khutorsky (possibly for the first time. – note by author), N.N. Surtaeva, P.V. Sysoev, S.A. Vdovina, and the term of personification of education – by N.E. Ogarev [6]. In 2005, V.V. Grachev wrote, "The idea of personalization runs like a golden thread through the formation of many innovative educational models… a personality-oriented approach, subject-subject interaction" [7, p. 15].

Gradually, a version has emerged in the theoretical pedagogical space that individualization of learning is the adaptation of learning parameters "for the student" carried out by the teacher, and personification (personalization) of learning is the adaptation of learning parameters carried out by the student [8; 9].

Considering the idea of developing individualization as a historical prerequisite for personalized learning, the authors [10] supplement the concept of personification with essential characteristics, such as the tutoring role of the teacher and the personally significant goals of the student. In [11], analyzing higher education in modern conditions, the authors clearly demonstrate an example of confusion between the concepts of personification and individualization. First, they assert that individualization, like personification, "positions the student as the main subject of educational activity" [11, p. 111], and then provide a table of differences between personalization and individualization, from which, it follows that with individualization of education, the student is an object in the educational process, and with personalization, he is an active subject.

Defining the essential characteristics of personification, the authors of the study [12] highlight among them the formation of a personalized educational environment addressed to the interests and needs of an individual student. Developing this approach in [13], they consider personalized learning as a new didactic principle in the postnonclassical understanding, when the subjectification of the student's role in the pedagogical process is supplemented with the axiological content of the value of interaction in the educational environment.

However, when describing pedagogical innovations, not all authors use the personalization-personification terminology to describe subject-subject relations in the pedagogical process. Many of them do with the term individualization, considering it exhaustive, for example, when analyzing the practice of individualization in modern pedagogical education [14]; when considering the psychological aspects of the relationship between the mechanisms of consciousness and individualization of learning [15]; when studying the problem of subjectification in the individualization of learning [16]. The examples given demonstrate the conceptual duplication in the individualization and personification terms used by researchers. This duplication of terms is recorded in the models of R.V. Komarov and T.M. Kovaleva [17].

Summarizing the review of studies, we see that the problem of confusing the concepts of an individual approach and individualization of learning, on the one hand, and individualization of learning and personification (personalization) of learning, on the other, requires resolution.

The aim of this study is to show that from a historical, essential and axiological point of view, the exclusion of the active subjective role of the student from the concept of individualization of learning is unreasonable, as is the reduction of the concept of individualization of learning to an individual approach.

METHODS

The logic of the study is based on the analysis of the evolution of the idea of individualization of education from the moment of its origin in the ancient period in the form of the idea of an individual approach to education to the moment of its implementation in the first individualized method of teaching – the Dalton plan, through periods of regression in the Middle Ages, revival through humanism in the Renaissance, development of naturalistic preferences in the Enlightenment, and proclamation of pedagogical ideas of "free development" and "personal experience" as a condition for the formation of an individual

[1] *Davydov V.V., ed. Rossiyskaya pedagogicheskaya entsiklopediya [Russian Encyclopedia of Pedagogics]. Moscow, Bolshaya Rossiyskaya entsiklopediya Publ., 1993. Vol. 1, 607 p. P. 358–607.*

in the industrial era. The study was conducted using the historical-genetic method and the method of historical periodization, guided by the principles of objectivity and relying on historical sources. The evolution of the idea of individualization is considered as the development of an alternative branch of pedagogy in its dialectical opposition to traditional views on pedagogy at all stages.

RESULTS

The ancient period

The term of individualization of learning appeared only about a hundred years ago, but an individual approach in education and upbringing has occupied the minds of educators since the origin of pedagogy. Even the ancient Roman theorist of oratory and educator Marcus Fabius Quintilian (1st century AD), devoting Chapter IX of his Rhetorical Instructions to an individual approach to students, spoke of the need to "charge the teacher with a virtue… to distinct the natural abilities of students."[2].

Many thinkers addressed the topic of an individual approach in education, although they intended different meanings and content of this concept. The idea of individualization in education itself was formed in several stages before it acquired its current content. One of the first meanings on the path to individualization in education was the necessity of seeing in the student, first, an individual with his own rights and dignity. Even this was not obvious in the era when the rod was considered the main means of persuasion and punishment of the student. In the ancient period of history, physical punishment was also a common thing. It is not surprising that M.F. Quintilian, who proclaimed the principle of an individual approach, unequivocally rejected physical punishment of pupils, "I do not approve of the custom of punishing children physically, although this is accepted by almost everyone... Such punishment seems to me vile and is characteristic only of slaves."[3]. Thus, the humanization of education is the first stage, the prerequisite for an individual approach to the student.

Middle Ages. Renaissance

In the Middle Ages that followed the ancient period, with its dominant religious content in all spheres of society, including education, the idea of humanizing education was initially rejected. This was primarily due to the dogmas of the Old Testament, which is the canonical origin of a belief for Christians. For example, in the Solomon's Proverbs, "Whoever spares the rod hates his son, but he who loves him is diligent to discipline him" (Proverbs 13:25). Many Christian thinkers up to the beginning of the 20th century – Augustine Aurelius (5th century AD), Ambrose of Milan (4th century AD), Peter Damascene (12th century AD), A.P. Lopukhin (1852–1904) in the Explanatory Bible, and Vissarion Nechaev (1823–1905) repeated subsequently this idea, and only with the advent of the Renaissance, the idea of humanizing education returned to pedagogical thought and practice. Anthropocentrism was proclaimed the ideal of the Renaissance, man and human life – the main value, and although, of course, several more centuries had to pass before this ideal was implemented, in the pedagogical ideas of the Renaissance, along with art, this was reflected. Vittorino da Feltre founded the House of Joy School (1423), the activities of which were based on the principle of respect for the personal dignity of students; Francois Rabelais (1494–1553) came out with the idea of comprehensive harmonious development of a child and criticism of the existing system of education described in the Gargantua and Pantagruel novel.

Michel de Montaigne (1533–1592) both continued the ideas of humanism in education, "Go into such a college during classes: you will hear nothing but cries – the cries of schoolchildren being flogged, and the cries of teachers… Is it possible to awaken in children a desire for study in this way…? A false and destructive method!"[4], and, perhaps for the first time, proclaimed the principle of the subjectivity of the pupil, which is today included in the concept of individualization. Montaigne calls for giving a child the opportunity to show his inclinations, "allowing him to find the road himself," and for the mentor "to also listen to his pupil"[5].

The Renaissance humanists, paying attention to the individuality of students, called for the need to consider their characteristics in the process of education, rejecting the medieval impersonal, often cruel methods of influencing students. The romantic perception of a student as an individual in the Renaissance was the first step towards realizing the value of an individual approach in education and upbringing and was an alternative branch of the established view of the educational system.

Pedagogy began its development with individual teaching, when a teacher worked with one or several students, but an individual approach was usually not used. It was naturally believed that there is knowledge that must be mastered by a student, and there are some methods that convey the essence of this knowledge to the student, and how the student will be able to perceive this knowledge is exclusively a problem of his abilities and hard work. First of all, this was a consequence of the inaccessibility of education and the limited demand for the level of education in the Middle Ages. Human intellectual resources had limited use: to satisfy the intellectual needs of that time, it was enough to educate the capable and rich, so education covered mainly the elite and the clergy.

In the Middle Ages, as the production forces developed in Europe, the demand for education grew. At the same time, two opposing religious movements, Catholicism and Protestantism, opened schools to expand their influence. The increased demand for education gave rise to new trends in pedagogy aimed at organizing mass flow education in the form of a class-and-lesson system, which were

[2] *Kvintilian M.F. Dvenadtsat knig Ritoricheskikh nastavleniy [Twelve books of rhetoric guidelines]. Sankt Petersburg, tipografiya Imperatorskoy Rossiyskoy Akademii Publ., 1834. 486 p. P. 117.*

[3] *Kvintilian M.F. Dvenadtsat knig Ritoricheskikh nastavleniy [Twelve books of rhetoric guidelines]. Sankt Petersburg, tipografiya Imperatorskoy Rossiyskoy Akademii Publ., 1834. 486 p. P. 29.*

[4] *Montaigne M. Opyty. Izbrannye glavy [The Essays. Selected chapters]. Moscow, Pravda Publ., 1991. 656 p.*

[5] *Montaigne M. Opyty. Izbrannye glavy [The Essays. Selected chapters]. Moscow, Pravda Publ., 1991. 656 p. P. 121.*

generalized and formulated by Jan Amos Comenius (1592–1670), who laid the foundation for mass school for several centuries to come. Despite the fact that J.A. Comenius, being a son of the Renaissance, continued the humanization of pedagogy, proclaiming the slogan "Children are the most precious heritage of God and an inestimable treasure"[6], education in the class-and-lesson system itself in most cases deprived teachers of the opportunity of individual approach to the education of students. The class-and-lesson system primarily solved the problem of maximizing the volume of education with limited pedagogical resources and opened the prospect of mass universal education for centuries to come. Moreover, the class-and-lesson system to a significant extent systematized the learning process and the knowledge acquired by students, and thanks to this it later became the main classical, subsequently recognized traditional, direction of education.

The Age of Enlightenment

A dialectical alternative to education according to the class-and-lesson system with the help of formed programs that do not differentiate between students arose thanks to the adherents of the "romantic" trend, who believed that education and upbringing should be adapted to a specific student. During the Age of Enlightenment, a prominent representative of this trend was Jean-Jacques Rousseau (1712–1778). He laid the foundation for romantic naturalism, which proclaimed that children develop in accordance with a special natural plan created by nature, and the task of the teacher and educator is not to interfere with the implementation of this plan, creating the conditions and prerequisites for its maximum embodiment. He proclaimed, "Childhood has its own, inherent ways of seeing, thinking and feeling; there is nothing more absurd than the desire to replace them with ours."[7].

Of course, this message is quite idealistic, even today, its implementation looks fantastic for mass application, but it set a certain alternative trajectory for the development of pedagogy. The followers of traditional education were improving programs and teaching methods and formulating general goals of education that were in demand by society, scaling education to various, new layers of the population. The followers of the individual approach were formulating concepts that would be in demand when pedagogy would begin to move from the slogan of universal education of the population (which was proclaimed by the Renaissance humanists and which would be implemented in developed countries at the beginning of the 20th century) to the modern idea of revealing the abilities of each student[8].

Industrial era

The followers of romantic naturalism, and later of "free development" were not only theorists, like J.-J. Rousseau. A bright practical implementer of this idea was the Italian educator Maria Montessori (1870–1952). She embodied these ideas in specific methods of development and education of children, the main provisions of which were based on the fact that each child is a unique, inimitable personality with its own plan of development, and it is necessary to adapt the process of education to the process of self-development. She wrote, "A child can reveal himself to us only by himself, freely implementing his natural plan of construction"[9]; "Freedom is the only means that always leads to the most complete character development"[10].

In Russia, a bright representative of the "free development" direction in pedagogy was the great Russian writer Lev Nikolaevich Tolstoy (1828–1910), who developed these ideas in the school he opened for peasant children in Yasnaya Polyana. L.N. Tolstoy proposed to provide the student with complete freedom "to perceive the teaching that corresponds to his demand, which he wants, and to perceive as much as he needs, as much as he wants, and to avoid the teaching that he does not need and which he does not want"[11]. Of course, such a radical understanding of "free development" can hardly be considered rational; rather, we evaluate it as a dialectical challenge, the extreme opposite of the conservative traditional approach in pedagogy, where every action of the student is prescribed and controlled by the teacher, where the student is a powerless passive object of the educational and upbringing process.

It took many centuries for human society to reach the level at which the state guaranteed compulsory education. This goal was achieved in the leading countries of the world at the turn of the 19th and 20th centuries, but the scientific and technological revolution required a higher level of education. Civilization gradually came to the idea that the most valuable economic resource is human capital, an integral part of which is the level of education [18]. The task of not just giving some education to everyone became relevant, but trying to use the existing human potential as efficiently as possible, giving the maximum possible education to those capable, striving to fully use those individual gifts and abilities that each member of society has. This means that education should be built in such a way as to reveal these individual abilities. Maybe, this idea itself is not new, but earlier in its history, humanity did not experience a deficit of intellectual resources, which began to arise everywhere in the 20th–21st centuries, especially in the post-industrial era, even despite the rapid growth of the planet's population, which, moreover, no longer affected developed countries.

[6] *Comenius J.A. Materinskaya shkola [School of Infancy]. Moscow, Gosudarstvennoe uchebno-pedagogicheskoe izdatelstvo ministerstva prosveshcheniya Publ., 1947. 103 p. P. 35.*

[7] *Rousseau J.-J. Emil, ili O vospitanii [Emile, or On Education]. Sankt Petersburg, Izdatelstvo gazety Shkola i Zhizn Publ., 1912. 491 p. P. 68.*

[8] *Medvedev D.A. Address of the President of Russia to Federal Assembly of the Russian Federation dated November 12, 2009. Prezident Rossii. URL: http://www.kremlin.ru/events/president/transcripts/5979.*

[9] *Montessori M. Deti – drugie [The Secret of Childhood]. Moscow, Karapuz Publ., 2004. 334 p. P. 28.*

[10] *Montessori M. Samovospitanie i samoobuchenie v nachalnoy shkole [Self-improvement and Self-education at Elementary School]. Moscow, Karapuz Publ., 2009. 200 p. P. 36.*

[11] *Tolstoy L.N. Polnoe sobranie sochineniy. Pedagogicheskie stati 1860–1863 [Complete collection of works. V. 8. Pedagogical articles 1860–1863]. Moscow, Khudozhestvennaya literature Publ., 1936. Vol. 8, 664 p. P. 155.*

The response to this challenge was the progressive trends in pedagogy striving for qualitative shifts in the level of education. One of such approaches in pedagogy was the focus on the "personal experience" of a student as opposed to the "ready-to-use experience" that dominates in traditional schools, transmitted by a teacher to a student. The main initiator of this idea was the American educator John Dewey (1859–1952), "Experience, even the smallest, is capable of generating and supporting even the most complex theory, but theory, unlike experience, cannot even be formulated properly."[12]. J. Dewey speaks not simply about experience, but about "active" experience, in which the student must actively act, and not just passively experience, "Experience inextricably combines attempts to act and living through the consequences of these attempts. Separating the stage of active action from the stage of passive living through its consequences, we destroy the vital meaning of experience."[13]. This approach in pedagogy, in addition to the well-known focus on the labor school, also laid the foundations for perceiving the student as a subject of the educational process, a paradigm that is today officially accepted as a standard of education in the world and in Russia within the framework of the system-activity approach[14]. The same principle of active personal experience, as we will see below, was the basis for the creation of the world's first system of individualized learning.

Dalton plan

The first implementations of the pedagogical idea of an individual approach in collective learning historically took place in America during the life of J. Dewey. Several similar teaching methods were proposed, which attempted to introduce individualized principles into school education with the class-and-lesson system. These are the Pueblo Plan (1888–1893) of the American educator P. Search in the city of Pueblo, the North Denver Plan (1898) of D. Van Sinkel, and the most famous systematically developed method of individualization of education was the teaching method called the Dalton Plan (1919). It was created and implemented by the American educator Elena Parkhurst and is still used in many schools around the world today. Justifying her teaching system, E. Parkhurst pointed to two principles underlying it: freedom in educational activity, realized by the student, and the construction of education based on individual and social experience[15]. These principles reflect the history of the development of the ideas of individualization – from the perception of a student as an individual and a person to the free self-realization of their individuality by students in the learning process. E. Parkhurst herself was a student of courses and assistant of M. Montessori in Italy in 1914[16] and a follower of the ideas of J. Dewey[17].

Analyzing education on the Dalton plan in terms of the content of the individualization principle embedded in it, we come to the conclusion that individualization, according to E. Parkhurst, contains an individual approach when studying in a general (or differentiated by levels) program through the independent construction of an individual curriculum by the student. In other words, the active subjective role of the student in the process of formulating the parameters of his/her training is an obligatory component in individualized education. What else is necessary for the term voiced by E. Parkhurst and implemented in practice by her in the principles described above to become a generally accepted definition of individualization of education? In addition to the fact that this is logical, it is also fair in relation to the merits of the great educator. At the same time, we see that the idea of individualization of education has gone through several stages in its evolution from the idea of an individual approach, and it is historically unreliable and essentially incorrect to draw an equal sign between them.

From the given historical insight on the development of the idea of individualization, it is clear that individualization of education itself is an alternative paradigm in education and is probably a reflection of the trend towards individualization of a person in society [18].

DISCUSSION

Based on the results of our study, we conclude that the definition of individualization of learning given in the Russian and Soviet Pedagogical Encyclopedias is incomplete. It is advisable to supplement its content with the need for an active subjective role of the student or the need for a systemic-activity approach enshrined in the Federal State Educational Standards of General Education. The reasons for the disappearance of this content from the concept of individualization of learning in the Soviet encyclopedia may lie in the unsuccessful attempt to introduce the Dalton plan in Soviet Russia in the 1920s and the negative attitude of Soviet ideology towards individualism, but this is a topic for a separate study. As a result of the restriction of the concept of individualization of learning, the term of personification appeared. It was borrowed from psychology and filled with the content lost by the term of individualization, which we saw in the works [8; 9; 11], and the term of individualization of learning itself was devalued to the concept of an individual approach, as was done in studies [1–3]. With our research, we call not to replace the concept of individualization with the concept of personification, but to fill the term of personification with new pedagogical principles complementing or separating it from the term of individualization. We have observed such attempts in

[12] *Dewey J. Demokratiya i obrazovanie [Democracy and Education]. Moscow, Pedagogika-Press Publ., 2000. 382 p. P. 138.*

[13] *Dewey J. Demokratiya i obrazovanie [Democracy and Education]. Moscow, Pedagogika-Press Publ., 2000. 382 p. P. 144.*

[14] *Federal State Educational Standard. Approved by order of the Ministry of Education of the Russian Federation dated May 31, 2021 No. 287 par. 4. Garant.ru: Legal information system. URL: https://www.garant.ru/products/ipo/prime/doc/401333920/.*

[15] *Parkhurst E. Vospitanie i obuchenie po Daltonskomu planu [Education on the Dalton Plan]. Moscow, Novaya Moskva Publ., 1924. 232 p. P. 19–20.*

[16] *Parkhurst E. Vospitanie i obuchenie po Daltonskomu planu [Education on the Dalton Plan]. Moscow, Novaya Moskva Publ., 1924. 232 p. P. 15.*

[17] *Parkhurst E. Vospitanie i obuchenie po Daltonskomu planu [Education on the Dalton Plan]. Moscow, Novaya Moskva Publ., 1924. 232 p. P. 20.*

the works [12; 13]. Otherwise, it is necessary to abandon the practice of using it, as the authors of [14–16] did. With our work, we do not simply state the mutual intersection of the content of concepts, as the authors of [17] did, but we provide arguments contributing to the ordering of the basic terminology, which should have a positive effect on the theoretical basis of science and facilitate its meaningful application by practicing teachers. We believe that cluttering up the science with new terms instead of filling it with new entities does not contribute to the development of the theoretical base even in the conditions of postnonclassical rationality, but turns theory into a table littered with papers, where it is impossible to find an important document at the right moment.

CONCLUSIONS

The results of the conducted research show that the term of individualization of learning has historically grown from the concept of an individual approach, supplemented with a new meaning, in particular the active subjective role of the student, and should not be confused with it. At the same time, in this meaning, the term of individualization of learning is meaningfully duplicated by the term personification (personalization) of learning, which came into use much later and, therefore, has no historical right to replace it. The content of the term of personification should be filled not with shades of meaning of the concepts of individualization, but with qualitatively new entities.

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Содержание термина индивидуализации обучения в контексте истории развития идеи индивидуализации в образовании

Павлов Сергей Валерьевич, аспирант
Русская христианская гуманитарная академия им. Ф.М. Достоевского, Санкт-Петербург (Россия)

E-mail: pvlsergey@mail.ru ORCID: https://orcid.org/0009-0008-6378-2480

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Аннотация: В теории педагогики продолжительное время существует неопределенность, связанная с содержанием термина индивидуализации образования. Различные авторы определяют и употребляют термин индивидуализации в разнообразных смыслах, зачастую имеющих не оттеночные, а принципиальные расхождения. Ситуация отчасти усугубляется тем, что в законодательной базе Российской Федерации термин прямо не определяется, а определение термина в Российской педагогической энциклопедии, практически заимствованное из Советской педагогической энциклопедии, является с исторической и методологической точки зрения неполным. В работе путем анализа этапов развития идеи индивидуализации образования формулируется содержание термина индивидуализации для решения проблемы существующих разночтений в определении этого термина и содержании индивидуализации в обучении. Выделено различие в содержании термина индивидуального подхода и индивидуализации обучения. История развития идеи индивидуализации рассматривается методом исторической периодизации с использованием историко-генетического подхода, позволяющего рассматривать тренд на индивидуализацию в образовании как диалектическую альтернативу системе традиционного обучения с момента зарождения понятия индивидуального подхода в обучении. Создание Е. Паркхерст первого индивидуализированного метода обучения,

Дальтон-плана, представлено как итог развития идеи индивидуализации в образовании. Полученные результаты, естественно, не создают нового понимания термина индивидуализации в образовании, а лишь научно обосновывают использование этого термина с определенным методологическим наполнением, который уже применяется частью педагогов. Предложенное в статье наполнение содержания термина индивидуализации в образовании позволяет исключить существующее дублирование и смешение понятий в этой области.

Ключевые слова: индивидуализация образования; индивидуализация обучения; индивидуальный подход; персонализация обучения; персонификация обучения; Дальтон-план; Паркхерст.

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A set of electronic graphic tasks on descriptive geometry adapted for automated assessment systems

Anna V. Petukhova*[1,2,3], PhD (Pedagogy), Associate Professor, assistant professor of Chair "Graphics"
Eduard V. Ermoshkin[1,2,4], senior lecturer of Chair "Engineering and Computer Graphics"
[1]*Siberian Transport University, Novosibirsk (Russia)*
[2]*Novosibirsk State University of Architecture and Civil Engineering (Sibstrin), Novosibirsk (Russia)*

***E-mail:** a.petukhova@sibsrtin.ru
[3]ORCID: https://orcid.org/0000-0002-7775-5220
[4]ORCID: https://orcid.org/0000-0002-5520-070X

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Abstract: The paper raises the problem of quality control of graphic training of technical university students using an automated assessment system. Despite wide access to digital educational resources, the acceptance and checking of drawings and calculation and graphic works in technical universities is still performed manually by teachers. The authors propose replacing the usual forms of graphic tasks on descriptive geometry with electronic metric and positional tasks of a new type. The result of solving such problems is expressed as a number or a short answer and can be compared with the standard using any standard testing system, for example, LMS Moodle. The work presents 20 examples of electronic practical tasks on descriptive geometry, the solution of which can be performed in any graphic editor, and the answer is checked using an automated assessment system. The set of electronic assessment tools developed by the authors contains more than 600 variants of graphic tasks and is designed to check theoretical knowledge and practical skills related to the content of the Descriptive Geometry and Computer Graphics course. The correctness of the tasks is checked automatically by means of the tools of the LMS Moodle electronic learning environment without the participation of the teacher. Pre-designed sets of control parameters, such as area, length, distance, volume, quantity, condition, and type are used for assessment. The system is successfully used for current monitoring of knowledge, skills and abilities of first-year students at the Siberian Transport University. The data from monitoring the learning outcomes indicate the effectiveness of the use of automated diagnostics of the level of development of students' graphic skills.

Keywords: set of electronic graphic tasks; Descriptive Geometry and Computer Graphics; automated assessment system; electronic assessment tools; digital educational resources; automatic checking.

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INTRODUCTION

The problem of assessing the quality of training has always been and remains one of the most discussed in the pedagogical environment. Diagnostic activities allow the teacher to obtain information on how successfully the student masters the educational material, to check the fact of the student's mastery of certain competencies, to identify the dynamics and trends in changing learning performance indicators. Providing external feedback and activating internal control are the most important functions of pedagogical diagnostics [1–3]. At the present stage, one of the priority areas in pedagogical research is the development of automated systems for assessing knowledge, skills and abilities, the development of electronic assessment tools, the use of digital educational resources, and the introduction of test forms of control [4–6].

The choice of the assessment procedure largely depends on the purpose of the assessment activities, as well as on how the assessment results are planned to be used in the future [7]. In the system of engineering and graphic disciplines, calculation and graphic works, graphic tasks and electronic models are used to assess the results of educational activities. Tasks in descriptive geometry, engineering and computer graphics and the results of their implementation are drawings. In modern realities, drawings are made mainly using CAD systems. Checking the graphic work by the teacher includes: loading the drawing file to the teacher's workstation; opening the file in a certain CAD system; analyzing the solution's compliance with the condition; critically understanding the course of action chosen by the student when solving the problem; identifying errors and shortcomings; assigning a grade; publishing a grade and review of the work. Considering the above, checking graphic tasks is a very labor-intensive operation, so there is an objective need to introduce automated systems for monitoring the level of development of graphic skills into the educational process [8–10].

There are several options for solving this problem: developing applications for automatic analysis of individual machine-readable parameters of an engineering drawing [9], using systems for automated comparison of drawings with certain standards of the correct solution [8; 10; 11], using the artificial intelligence capabilities [12], developing graphic applications with built-in drawing checking tools [8; 13; 14], and using electronic testing systems [15–17].

Processing a bitmap image obtained from a visual image of a drawing is one of the common ideas for automatic assessment. For example, the Virtual Teaching Assistant (ViTA) system is able to assess student works exported from various engineering graphic editors and recognize the most common types of errors, such as incorrect contour or scale, incorrect thickness or type of lines, irregularities in the arrangement of images, irregularities in the composition of images [9]. The assessment of a student work is performed based on comparison with a standard sample previously loaded by the user. Virtual Teaching Assistant (ViTA) has shown good results when checking educational technical drawings containing two-dimensional images of drafting views, sections and cuts (engineering graphics). However, the limitations of the program make it difficult to check works related to the Descriptive Geometry section, since the solutions to most metric and positional problems contain many auxiliary elements, the arrangement of construction lines is variable, the geometric composition of the solution depends on the sequence of actions chosen by the students and can have many visual differences with an unambiguously correct solution to the problem.

Another idea of automating the assessment of graphic work is related to the use of systems of visual comparison with a solution standard [10]. A special program searches for missing or faulty elements in the solution based on a comparison of visual clones of the checked drawing and the standard sample. An undoubted advantage of this method is the possibility of batch comparison. A disadvantage is the lack of intelligence of the human evaluator. The use of this method is justified if the correct solution to the graphic problem contains one constant set of graphic primitives, a certain combination of which creates an unchangeable graphic image of the drawing. If the correct solution to the graphic task can be obtained in several variable ways, with different sets of geometric primitives and their combinations, then the use of this method seems somewhat difficult.

An interesting idea of automating the assessment of graphic works is the use of non-text databases containing arrays of reference images and images containing errors. The procedure of checking is implemented using an element-by-element comparison of the bitmap of the checked work with reference images and with erroneous images [11]. The assessment criteria are compositional patterns such as proportions, center, symmetry, and contrast. The degree of accuracy depends on how great the diversity of samples is. Therefore, a necessary condition for the correct operation of the system is the presence of a large number of structured and labeled graphic images. A limitation of the approach is the impossibility of using a clear true/false criterion parameter, which complicates the use of this method for automatic assessment of work completed by students during the study of engineering disciplines.

One more approach to automating the checking of graphic works is associated with the development of special extension programs for standard CAD systems. A rather successful example is an application designed to work in the AutoCAD software product [14]. The application is written in AutoLISP, allows the user to initiate automatic construction of a set of graphic primitives, which are the initial data of the graphic task, gives the student access to the use of built-in AutoCAD drawing tools, checks the correctness of the drawing, and displays the assessment and feedback on the screen. Significant limitations of this technology are narrow specialization – the program works only with the AutoCAD program; a narrow range of topics in descriptive geometry for which tasks have been implemented; lack of access to the program for a wide range of users.

Another way to automate the procedures for checking graphic tasks is associated with the development of electronic testing systems [6; 16–18]. Tests are one of the most productive means of optimizing pedagogical work. The main difficulty related to the use of test forms of control in Descriptive Geometry and Computer Graphics is caused by the fact that the result of solving a problem is always a set of lines and points, and publicly available electronic educational systems are not designed to process data presented in the form of graphic elements. Therefore, the use of automated systems for assessing graphic works requires the transformation of the tasks themselves, the development of new formulations of problems in which the result of solving the problem is a drawing containing a certain control parameter. A new approach to the formation of graphic tasks will reduce the teacher's time costs by eliminating routine operations associated with downloading drawing files, opening them, and checking them against the solution standard.

The purpose of the study is to develop a set of electronic graphic tasks adapted for use together with publicly available automated assessment systems.

METHODS

Research Materials

The material for this study was the funds of assessment tools used to control the level of development of graphic skills of first-year students studying in 23.05.04 Transportation Process Management training program [19].

Stages of the Research

The research methodology included:

– analysis of assessment tools in descriptive geometry, their systematization;

– development of technology for monitoring of practical skills of students;

– selection of learning performance indicators;

– selection of tasks, their adaptation for the electronic testing system, selection of the form for presenting tasks;

– development of a sufficient number of versions of each task;

– creation of a database, placement of tasks in the electronic educational environment, setup of the electronic testing system;

– conducting training sessions with students on the use of a new system for assessment of graphic skills, conducting control activities, analyzing intermediate results;

– identification and correction of unsuccessful tasks;

– general analysis of the results of applying the developed technology.

Performance Indicators

When developing the set of electronic graphic tasks, the authors took into account that the performance indicators of training descriptive geometry are the student's ability to find projections of points and lines belonging to a plane or surface; the ability to construct intersection lines or points of contact of two or three objects located in space; the ability to determine the visibility of elements on an orthogonal drawing; the ability to perform additional constructions necessary to determine the distances between objects or their sizes.

The assessment scales are designed using a standard system based on four levels of mastering the educational material: unsatisfactory – satisfactory – good – excellent. The unsatisfactory grade was used if the student could not confirm the ability to solve typical tasks in all tests. The satisfactory grade was given to a student who demonstrated the ability to solve typical graphic tasks. If the student demonstrated the ability to solve combined-type tasks (including many elements of typical tasks), he was assigned the good grade. If a student is able to synthesize new problem-solving techniques based on their previous experience, the level of mastery was interpreted as excellent.

A high level of task variability was ensured by the previously developed system of automatic generation of task variants using sets of parametric templates [20].

Testing of a Set of Electronic Graphic Tasks

The proposed technology for automated assessment of students' practical skills was tested in 2023 at Siberian Transport University. First-year students (124 people) participated in the testing. During the semester, students completed 20 graphic tasks packed in test forms. All tasks were posted in the e-learning system. The KOMPAS CAD system was used to develop and solve the tasks. The grade was assigned automatically. Each task was assessed individually (separately, regardless of the others).

The tasks were completed by students in the classroom in the presence of a teacher. The time limit was one class (90 minutes). The number of attempts was not specified. The maximum score for completing the task was 100 points. The final grade depended not only on whether the correct result was obtained, but also on how many attempts it took the student to get the right solution. The maximum grade of 100 points was given to a student who completed the graphic task without errors the first time. If the student completed the task correctly, but not immediately, after one or more corrections, then the number of points awarded for the task was reduced proportionally to the number of attempts. The task was considered passed if the student managed to score 70 points or more (i. e. the correct answer was obtained at least on the third attempt).

The result was assessed automatically, without the teacher's involvement.

RESULTS

Composition of the Developed Materials

The authors developed a set of electronic graphic tasks, including 20 tasks covering all sections of the Descriptive Geometry and Computer Graphics course. 30 options are offered for each task. All tasks are formulated in such a way that the answer is expressed as a number or a simple phrase (selected from the proposed list). Automatic checking of tasks by one or several control parameters has been configured. Table 1 provides a specification of tasks, describes the general content of the task, presents a sample of the graphic part of the condition, and indicates the control parameter and its type. The content of the tasks fully corresponds to the structure of the calculation and graphic work performed during the semester. One should note that the specific content of the task in each of the 30 options is different. Table 1 provides only general information about the tasks. Examples of specific electronic tasks are shown in Figs. 1–3.

To organize automatic control, standard test forms available in most e-learning systems were used: task with a numerical answer, selection of missing words and nested answers.

Task with a numerical answer contains a field for entering an answer, the answer must be a number. The task condition can be presented as text or be added to the question as an attached file. Fig. 1 shows an example of a graphic task of this type.

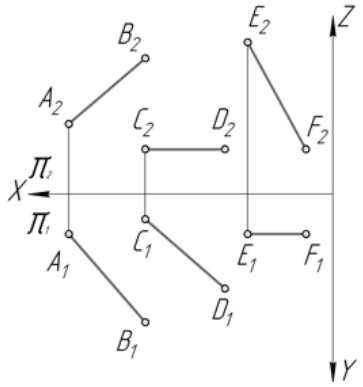
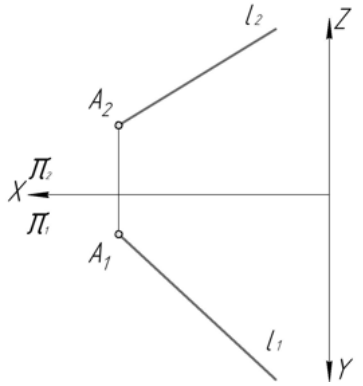
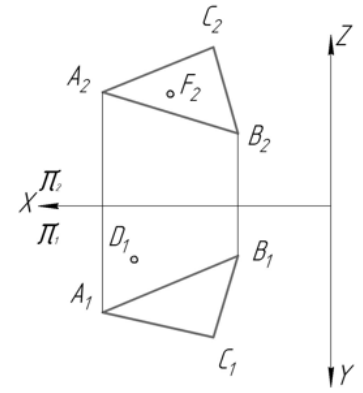
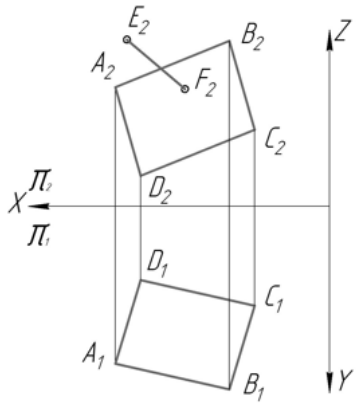
Selection of missing words is a closed-type task; the student selects an answer from a drop-down list containing a list of answer options. This type of assignment is convenient to use in graphic tasks on determining the visibility or relative position of objects. An example of using drop-down lists to issue a graphic task is shown in Fig. 2.

The third form of an electronic graphic task is nested answers. Allowed field types are Numerical Answer and Choice from List. The Numerical Answer type field requires entering an answer from the keyboard, the Choice from List type field allows the student to choose among the proposed answer options. An unlimited number of fields can be added to each task. An example of a graphic task created using the nested answers form is shown in Fig. 3.

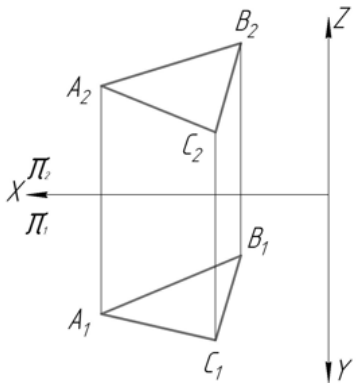
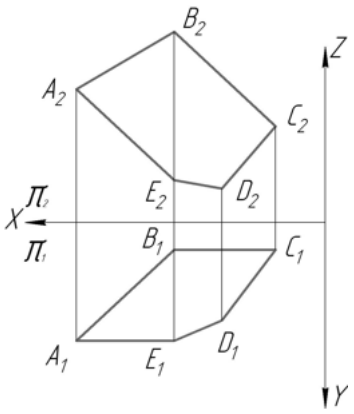
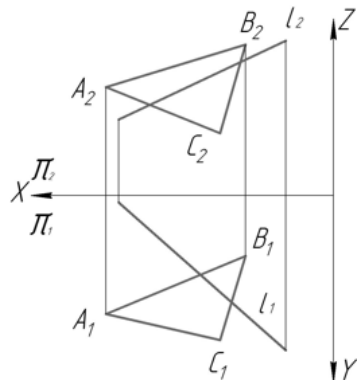
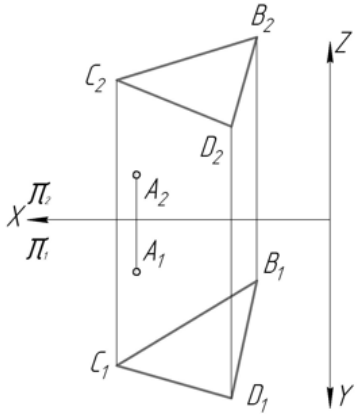
Test Results of the Approbation

Table 2 presents sample data on the execution of tasks by Student 1 (a "fairly good" student, has a high performance score in all subjects, average performance is 86 %), Student 2 (an "average" student, average performance in all subjects is 62 %), and Student 3 (a "fairly poor" student,

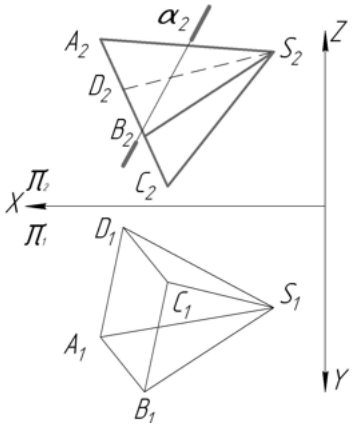
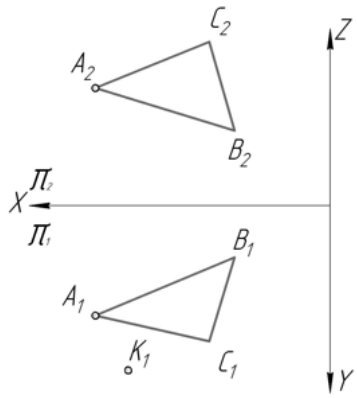
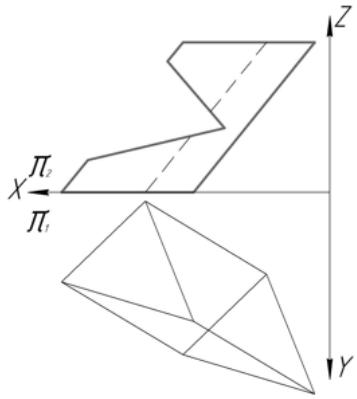
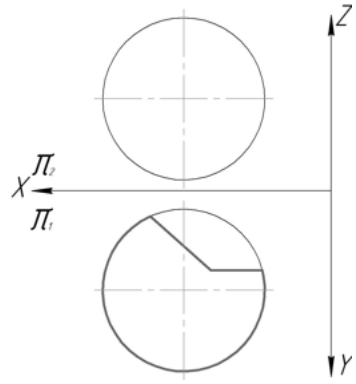
Table 1. *A set of electronic graphic tasks*
Таблица 1. *Комплекс электронных графических заданий*

Task, No.	**Condition of a problem, text part**	**Condition of a problem, graphical part, example of one of the options**	**Control parameter (*parameter type*)**
1	Find the actual sizes of the segments *AB*, *CD* and *EF*. Indicate the position of each of the segments in space		Actual size of the segment (*numerical*) Position in space (*choice:* contour line, general position line)
2	Plot along a general position line a segment *AB* of a given value (the specific value is indicated in the task option)		Point *B* coordinates (*numerical*)
3	Construct the projections of points *D* and *F* belonging to the plane specified in the drawing. What are the coordinates of the points obtained?		Point *D* coordinates (*numerical*). Point *F* coordinates (*numerical*)
4	Construct the projections of segment *EF* belonging to the given plane. What is the actual size of segment *EF*?		The length of segment *EF* (*numerical*)

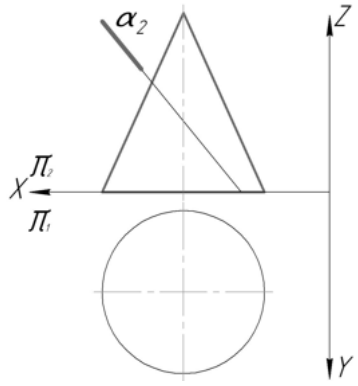
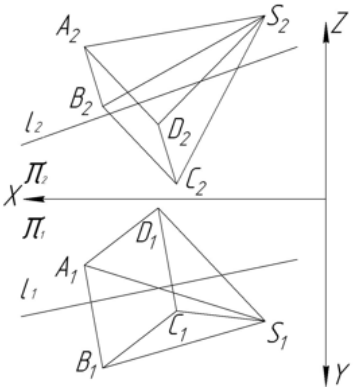
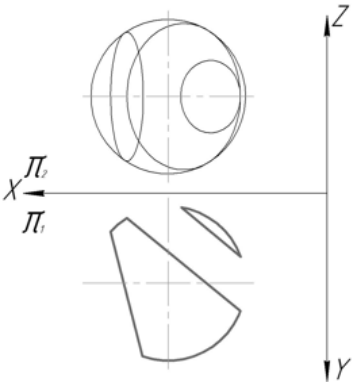
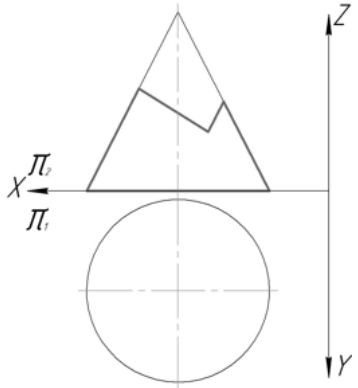
Continue of the Table 1

Task, No.	Condition of a problem, text part	Condition of a problem, graphical part, example of one of the options	Control parameter (parameter type)
5	The projections of plane *ABC* is given. It is required to construct a segment *AK* perpendicular to it (particular length of the segment is specified in the task option)		Point *K* coordinates (*numerical*)
6	Find the actual size of the flat polygon *ABCDE*		Area of the figure (*numerical*)
7	Find the point of intersection of the line *l* with the plane *ABC*		Intersection point coordinates (*numerical*)
8	Find the distance from point *A* to plane *BCD*		Distance (*numerical*)

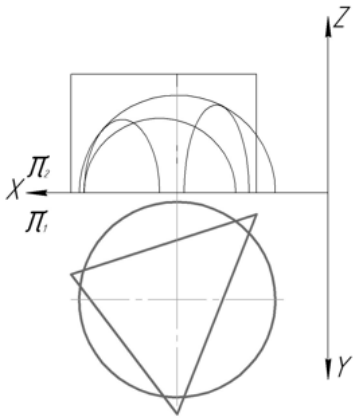
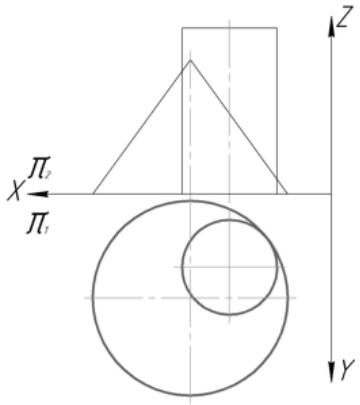
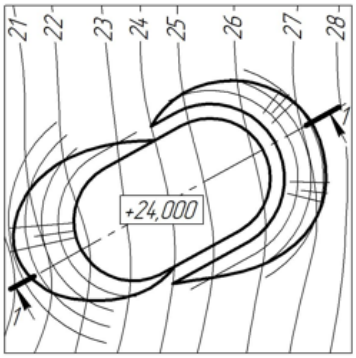
Continue of the Table 1

Task, No.	Condition of a problem, text part	Condition of a problem, graphical part, example of one of the options	Control parameter (parameter type)
9	Construct a section of the pyramid *SABCD* by plane α. What is the actual size of the section?		Area of the section (*numerical*)
10	Construct the projections of the pyramid *SABC*. The base of the pyramid is the triangle *ABC*. The height of the pyramid is the edge *AS*. *AS=BC*. Determine the visibility of all edges of the pyramid. Construct the missing projection of the point *K* belonging to the visible face of the pyramid		Apex *S* coordinates (*numerical*). Visibility *SA, SB, SC, AB, BC, AC* (*choice:* visible, invisible). Point *K* coordinates (*numerical*)
11	Construct the projections of a through flat cutout on the surface of a polyhedron. Find the actual size of the flat cutout (the area of one of the flat sections (any) or the total area of the entire cutout)		Area of the section (*numerical*)
12	Construct the projections of a through flat cutout on the surface of a sphere. Find the actual size of the section (the area of one of the flat sections (any) or the total area of the entire cutout)		Area of the section (*numerical*)

Continue of the Table 1

Task, No.	Condition of a problem, text part	Condition of a problem, graphical part, example of one of the options	Control parameter (*parameter type*)
13	Construct the line of intersection of the plane α and a cone. Determine the type of a curve. Construct the actual size of the section		Curve type (*choice:* parabola, hyperbola, ellipse, circle, line). Intersection line length (*numerical*)
14	The drawing shows projections of the polyhedron. It is shown without regard to the visibility of elements. Determine the visibility of the edges of the polyhedron. Find the points of contact of the line *l* and the polyhedron *SABCD*		Visibility of edges (*choice*: visible, invisible). Coordinates of points of contact of the line with the surface *SABCD* (*numerical*)
15	Two projections of a sphere truncated by planes are given. Determine the visibility of elements of the truncated sphere on plane Π2		Visibility of lines (*choice*: visible, invisible)
16	The cone is truncated by two planes. Plot the missing lines on the horizontal projection. What is the shape of the flat sections? Find the actual size of the section (the area of one of the flat sections (any) or the total area)		Curve type (*choice:* parabola, hyperbola, ellipse, circle, line). Area of the section (*numerical*)

Continue of the Table 1

Task, No.	Condition of a problem, text part	Condition of a problem, graphical part, example of one of the options	Control parameter (parameter type)
17	Projections of two intersecting bodies are given in the drawing. It is necessary to determine the visibility of all elements of the drawing		Visibility of lines (*choice*: visible, invisible)
18	Construct the line of intersection of two quadratic surfaces		The length of the intersection line (*numerical*)
19	The design parameters of the site (elevation mark, dimensions, and slope grades) and the topographic surface contour lines are given. It is necessary to construct the boundaries of earthworks. What is the area of the building on the plan plot?		Area of the building on the plan plot (*numerical*)
20	A drawing of an engineering structure is given. It is required to construct a profile along the line 1–1. What is the area of the fill and the cut on the profile?		Sectional area of the fill on the profile (*numerical*). Sectional area of the cut on the profile (*numerical*)

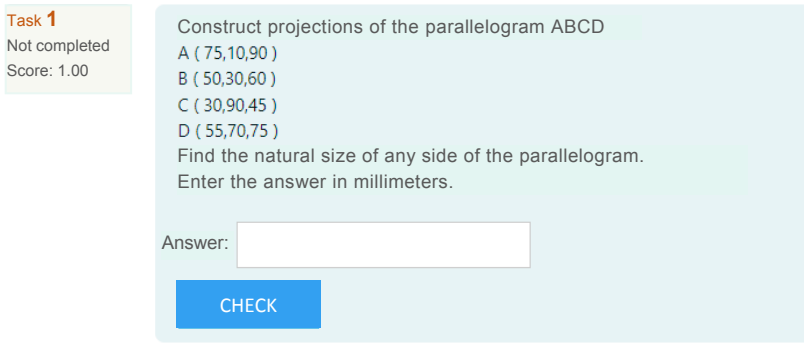


Fig. 1. *Graphic task with a numerical answer*
Рис. 1. *Графическая задача с числовым ответом*

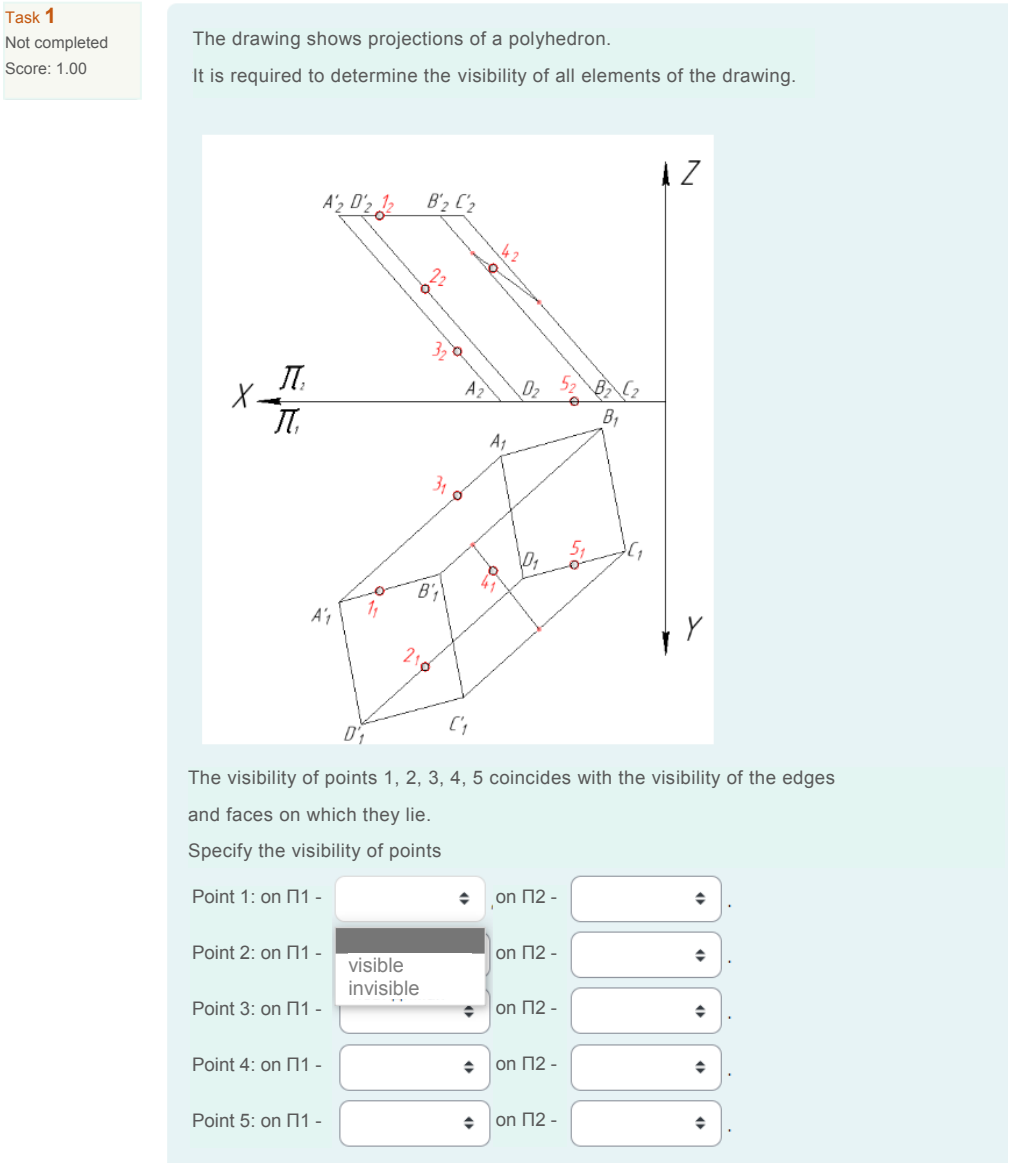


Fig. 2. *Graphic task with choosing words from a list of answers*
Рис. 2. *Графическая задача с выбором слов из списка ответов*

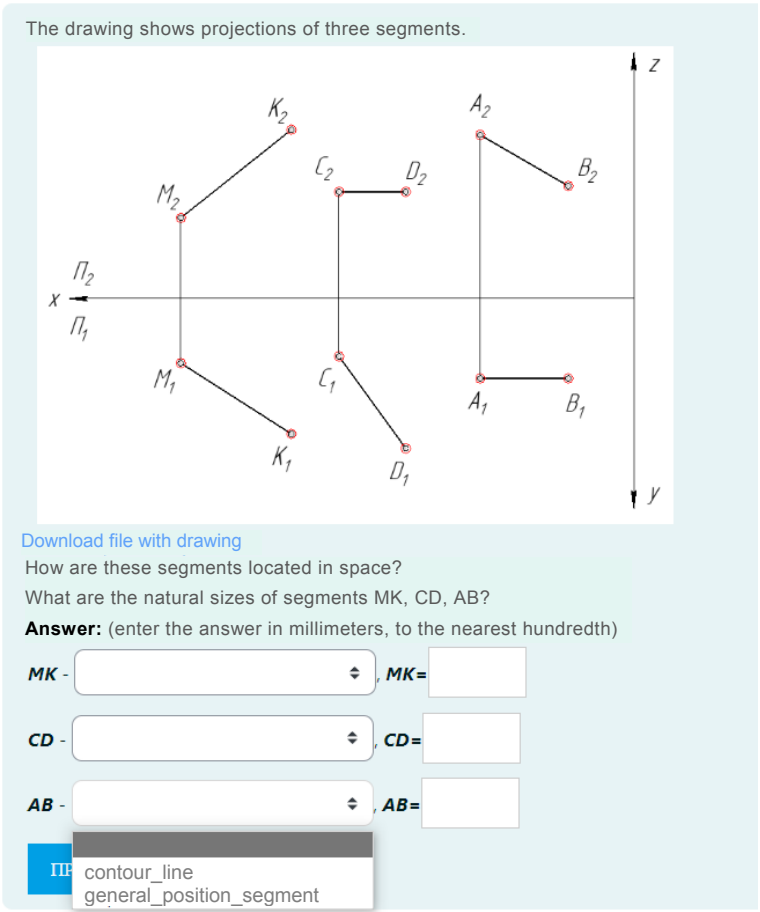


Fig. 3. *Graphic task with nested answers*
Рис. 3. *Графическая задача с вложенными ответами*

Table 2. *Sample data for three students*
Таблица 2. *Выборочные данные по трем студентам*

Student	Attempt, No.	Task, points																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
“Good”	1	100	100	80	100	100	100	100	20	100	80	40	80	100	100	100	100	100	100	100	100
	2			100					100			100									
“Average”	1	100	40	0	40	100	0	100	100	60	100	40	100	100	0	100	20	100	100	100	90
	2		60	50	100		100			100		100			100		60				
	3		100	100													100				
“Poor”	1	100	0	50	0	80	20	0	100	0	0	100	0	0	0	40	90	0	100	0	0
	2		40	100	0		20	60		0	20		0	60	0	20		50		20	0
	3		80		60		60	100		20	100		20	80	100	50		100		80	0
	4				80		60			60			60			90					60
	5						80			100			80								80

average performance in all subjects is less than 41 %). The data provided is actual. The names of students are not provided for ethical reasons.

The task numbers in Tables 1 and 2 coincide. The rows of Table 2 show the scores for each attempt. If a cell is empty, the attempt was not made by this student. Within one attempt, the student completed one of the task versions and could correct his answer as many times as he wanted (adaptive mode). In subsequent attempts, the student was automatically given a new version of the same task. The value "0" indicates that the student was unable to get the correct answer within the allotted time (one class, 90 minutes), i. e. the task was not completed. 100 points mean that the student completed the task correctly the first time; 90 points mean that the student corrected his answer once; 80 points – the student redid the solution twice, etc. The values of 10, 20, 30, 40, 50, 60, 70, 80, 90 points indicate that the student got the correct answer when completing the graphic task, but was unable to do it on the first try.

As one can see from the data given in Table 2, the "good" student coped with most of the tasks on the first attempt (scores greater than "0"). The "average" student had difficulties when completing several tasks. The "poor" student was able to get the correct answer to 9 out of 20 proposed tasks on the first attempt. At the same time, when completing tasks No. 3, 6 and 15, the "poor" student was unable to overcome the 70-point mark (pass grade) in the first approach and was forced to train until an acceptable result was obtained.

Fig. 4 shows the average data for the entire cohort of students (124 people).

DISCUSSION

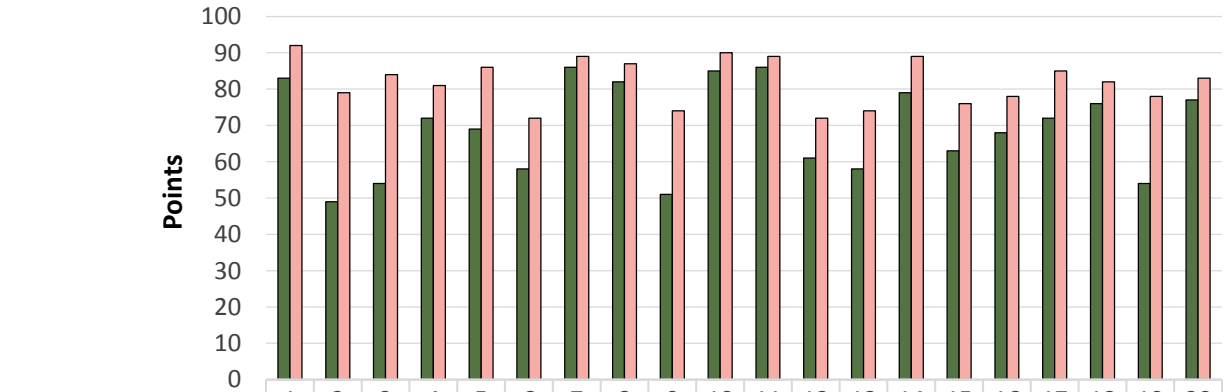
The obtained data indicate that the set of electronic graphic tasks successfully fulfills its function, allows checking the formedness of knowledge, skills and abilities related to the content of the Descriptive Geometry and Computer Graphics course. The proposed control method is a convenient tool for pedagogical diagnostics, allows relieving the teacher from performing many routine operations. Due to the introduction of the automated assessment system into the educational process, the structure of the Descriptive Geometry and Computer Graphics course has been optimized, losses of classroom time associated with delays in reviewing and checking drawings have been eliminated.

During testing, it was found that electronic tasks in descriptive geometry, packed in test forms, could be used both as an assessment tool and as a training resource (electronic simulator). Students actively use the opportunity to take training tests, independently sharpening their skills in solving graphic tasks. This is facilitated by the ability to immediately receive a grade for the task, the ability to make corrections to the solution and re-check the answer, as well as a large number of options developed for each task.

Compared with technologies based on computer vision and with technologies that involve comparing the visual image of a graphic work with a reference solution [9–11], the proposed technology for automatic assessment of graphic tasks has a number of advantages:

– reliability (the assessment does not depend on how similar or different the drawing made by the student is to the reference; if the solution is correct, the correct answer is received, then the attempt is counted regardless of the composition of graphic primitives in the drawing, their placement and positioning);

– independence from third-party developers (the assessment technology does not provide for the use of special applications, databases or comparison algorithms; the whole idea is built on the use of the standard functionality of the electronic testing system). In spite of the fact that automated drawing checking technologies that include the use of specially developed programs and applications [13; 14] may probably have a more interesting range of functions, the system proposed by the authors may be of interest to a larger number of fellow practitioners, since it is based on the familiar electronic testing and requires from



Task number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
First attempt	83	49	54	72	69	58	86	82	51	85	86	61	58	79	63	68	72	76	54	77
Last attempt	92	79	84	81	86	72	89	87	74	90	89	72	74	89	76	78	85	82	78	83

Fig. 4. *Average results of completing tasks*
Рис. 4. *Усредненные результаты выполнения заданий*

the teacher only creative thinking and the ability to create electronic tests. To implement the proposed automation technology, no additional applications, programs or databases are required. The system can be adapted to almost any course structure and software used.

Obviously, the proposed idea of automating the assessment of graphic works has a number of limitations:

– to increase the degree of reliability of the assessment, each task should have many variations, otherwise the correct answers expressed by a number or a short review become known to the student very quickly, and the tasks no longer perform their control function;

– there are a number of tasks for which the authors were not able to find an adequate version of the test task (for example, tasks included in the Method of Perspective Projections unit of descriptive geometry and tasks related to the implementation of projection drawings of parts and assembly units (engineering graphics)).

From a practical point of view, the developed system turned out to be quite effective. Teachers note the ease of use, reliability, high degree of variability of tasks, and assessment adequacy. Students consider this method of presenting graphic assignments to be quite comfortable, and the grading system to be fair (the grade is not affected by such factors as the student's previous achievements, his reputation, and the teacher's mood at the time of the assessment, etc.).

CONCLUSIONS

The authors formulated and implemented an idea according to which graphic tasks on descriptive geometry, packed into test forms, can be assessed automatically if a certain control parameter expressed as a number or a short answer is assigned to each task.

A database of graphic tasks consisting of 20 sets of tasks has been developed. Each set includes 30 task options. A total 600 variations of electronic graphic tasks with automatic checking have been prepared, which ensures a certain level of individualization of control measures.

The system is an original development and can be used in any educational institutions with the same or similar training programs in the Descriptive Geometry discipline.

As a result of testing, it was found that graphic tasks in electronic format effectively perform two main functions – control and training.

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Комплекс электронных графических заданий по начертательной геометрии, адаптированных для автоматизированных систем оценивания

Петухова Анна Викторовна*[1,2,3], кандидат педагогических наук, доцент, доцент кафедры «Графика»
Ермошкин Эдуард Валерьевич[1,2,4], старший преподаватель кафедры «Инженерная и компьютерная графика»
[1]*Сибирский государственный университет путей сообщения, Новосибирск (Россия)*
[2]*Новосибирский государственный архитектурно-строительный университет (Сибстрин), Новосибирск (Россия)*

***E-mail:** a.petukhova@sibsrtin.ru
[3]ORCID: https://orcid.org/0000-0002-7775-5220
[4]ORCID: https://orcid.org/0000-0002-5520-070X

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Аннотация: Поднимается проблема контроля качества графической подготовки студентов технического университета с помощью автоматизированной системы оценивания. Несмотря на широкий доступ к цифровым образовательным ресурсам, прием и проверка чертежей и расчетно-графических работ в технических университетах до сих пор выполняются вручную преподавателями. Авторы предлагают заменить привычные формы графических заданий по начертательной геометрии электронными метрическими и позиционными задачами нового типа. Результат решения таких задач выражен числом или коротким ответом и может быть сличен с эталоном с помощью любой стандартной системы тестирования, например LMS Moodle. В работе представлено 20 примеров электронных практических заданий по начертательной геометрии, решение которых может быть выполнено в любом графическом редакторе, а ответ проверяется с помощью автоматизированной системы оценивания. Разработанный авторами комплекс электронных оценочных средств содержит более 600 вариантов графических задач и предназначен для проверки теоретических знаний и практических навыков, связанных с содержанием курса «Начертательная геометрия и компьютерная графика». Проверка правильности выполнения заданий производится автоматически посредством инструментов электронной обучающей среды LMS Moodle без участия преподавателя. Для оценивания используются заранее спроектированные наборы контрольных параметров, такие как площадь, длина, расстояние, объем, количество, состояние, вид. Система успешно применяется для текущего контроля знаний, умений и навыков первокурсников в Сибирском государственном университете путей сообщения. Данные мониторинга результатов обучения свидетельствуют об эффективности применения автоматизированных средств диагностики уровня сформированности графических навыков студентов.

Ключевые слова: комплекс электронных графических заданий; начертательная геометрия и компьютерная графика; автоматизированная система оценивания; электронные оценочные средства; цифровые образовательные ресурсы; автоматическая проверка.

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The impact of rural school support on teachers' sense of efficacy

Zhen Ying*[1,2,4], doctoral candidate, Faculty of Education,
lecturer of College of Education Science, tutor of master students
Zhao Min[2,5], graduate student, Elementary Education, College of Education Science
Chen Xi[3,6], lecturer, School of Marxism
Zheng TingTing[2,7], graduate student, Elementary Education, College of Education Science
[1]*Northeast Normal University, Changchun (China)*
[2]*Mudanjiang Normal University, Mudanjiang (China)*
[3]*Mudanjiang Medical University, Mudanjiang (China)*

***E-mail:** 2018023@mdjnu.edu.cn

[4]ORCID: https://orcid.org/0000-0002-1484-8139
[5]ORCID: https://orcid.org/0009-0007-8250-2918
[6]ORCID: https://orcid.org/0009-0006-9800-6364
[7]ORCID: https://orcid.org/0009-0006-2101-0832

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Abstract: In order to investigate the impact of rural school support on teachers' sense of efficacy, how rural school support affects teachers' sense of efficacy, and whether there is a significant difference in the impact of different school support situations on teachers' sense of efficacy, a study was conducted in rural schools in a region of Heilongjiang Province. The study found that: (1) there is a significant positive correlation between teacher efficacy and rural school support. (2) Rural school support and its elements have a significant independent effect on teachers' sense of efficacy. (3) Different levels of rural school support have different impacts on teachers' sense of efficacy, and high levels of school support have a greater impact on teachers' sense of efficacy. In order to improve rural teachers' sense of efficacy, rural schools need to optimize the structure of the school support system and strengthen the construction of the teacher team; secondly, they need to improve the institutional support to enhance teachers' sense of efficacy; and thirdly, they need to pay attention to the role of professional support on teachers' sense of efficacy. Based on this, the improvement of education quality and equity can be promoted through the enhancement of teachers' sense of efficacy.

Keywords: teachers' sense of efficacy; school support; rural schools.

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INTRODUCTION

The reasons for the study

The Opinions of the Central Committee of the Communist Party of China and the State Council on Comprehensively Deepening the Reform of Teacher Construction in the New Era[1] clearly state that the status and treatment of teachers should be continuously improved, so as to truly make teaching an enviable profession. In his speech at the National Education Conference, General Secretary Xi Jinping emphasized that "as the conditions for running schools continue to improve, education investment should be tilted more toward teachers, and the treatment of teachers should be continuously improved, so that the majority of teachers can teach with peace of mind and enthusiasm." The stronger the education support the more it can enhance teachers' sense of efficacy. From this, it can be seen that improving teachers' sense of efficacy has become an important task in the reform of teacher team building in the new era. However, in the face of current development requirements, and despite the continuous advancement of current educational policies and practices, the construction of the teaching force still faces challenges in many aspects, especially the enhancement of teachers' sense of efficacy. This is not only related to teachers' personal development and professional satisfaction, but also to the overall improvement of education quality and the realization of educational equity.

[1] *Central Committee and the State Council of the Communist Party of China. Opinions on Comprehensively Deepening the Reform of Teacher Construction in the New Era (January 20, 2018). The State Council the People's Republic of China. URL: http://www.gov.cn/zhengce/2018-01/31/content_5262659.htm.*

Rural education plays a pivotal role in China's education system, and its level of development has a direct bearing on the overall balance of the country's education and the prospects for the growth of children in rural areas. However, the reality is that due to the accumulated historical problems, the uneven economic development and the complexity of the social structure, rural schools have encountered many difficulties in obtaining educational resources, obtaining support from schools, and building a high-quality teaching team. In particular, teachers' sense of efficacy, a seemingly abstract but critical indicator, is becoming a bottleneck that hinders the improvement of the quality of rural education. Teachers' sense of efficacy not only affects their teaching motivation and innovative spirit, but also determines, to a certain extent, whether rural education can realize a qualitative leap. Therefore, how to effectively enhance the sense of efficacy of rural teachers has become a key issue in promoting the development of rural education and realizing educational equity. This requires not only support at the policy level, but also extensive attention and active participation from all sectors of the society, so as to jointly inject new vitality and hope into rural education.

It has been found that 17.8 % and 20.3 % of in-service teachers in rural areas have a willingness to change schools and a willingness to withdraw from the teaching profession [1], while the willingness of young teachers to move is even stronger [2]. This suggests that the current state of teacher efficacy in China is not satisfactory. This raises a critical question: does rural school support promote a positive sense of teacher efficacy? More importantly, is there a significant difference in the influence of different school support situations on teachers' sense of efficacy? Therefore, based on the above questions, this study uses empirical analysis as a means to try to reveal the relationship between school support and teacher efficacy, and to explore the differences in the influence of different levels of support on teachers' sense of efficacy. We hope to find out the key factors affecting teachers' sense of efficacy and put forward practical suggestions to help improve teachers' overall sense of efficacy, thus promoting the improvement of education quality and the realization of education equity.

Theoretical analysis and research hypotheses

1. Social support theory

In the process of promoting the growth of teachers in rural schools, a key element is to create a harmonious and stable educational environment. Although there is still a lack of systematic theoretical discussion on "school support" in the academic world, the theoretical framework of "social support" is quite mature and widely recognized. In view of this, this study draws on the richness of social support theory as a basis for constructing a theory of school support that enhances teachers' sense of efficacy. By introducing the perspective of social support theory into the school support system, this paper aims to explore how to provide teachers with more effective help and support at the school level, so as to promote teachers' professional development and enhance their sense of teaching efficacy.

The concept of social support was first introduced and explained in detail in the literature of the discipline of psychiatry in the 1970s[2]. Subsequently, it was gradually embraced and used by other disciplines such as education and psychology. Then the concept of social support has been defined in past studies mainly in terms of social relations, the nature of social behavior, and the role of social resources [3]. From the perspective of social relations, social support a kind of exchange behavior based on interpersonal interaction, reflecting the mutual support relationship between people; from the perspective of the nature of social behavior, it is a kind of positive force to promote the development of the individual in the social environment; from the dimension of social resources, the concept of social support should contain three key elements: the source of support, specific behavioral behaviors or activities, and the individual's subjective evaluation of support. It is obvious that scholars have analyzed and discussed the theory of social support in depth from multiple perspectives and levels. Social support is a multidimensional system consisting of support providers, support recipients, and mediating factors. Among them, the support provided by the support provider to the service recipients is divided into two types: one is the obvious and observable objective support; the other is the support based on emotional experience and subjective feelings [4]. As a subsystem of society, schools provide critical support resources for teachers' growth, and some researchers have identified a "two-level, five-dimensional" analytical framework: first, objective support, including institutional support, conditional support, activity support, and cultural support; and second, subjective support, which mainly refers to emotional support. Based on this, this study locates four dimensions of school support: emotional support, material support, institutional support and professional support.

School support is essential to the personal growth of students and teachers. By creating a positive school climate and implementing effective management practices, schools are able to provide an environment full of opportunities and challenges for teachers and students, thereby promoting their development and progress. School support is the care and assistance given by the school to teachers in their professional endeavors, and the creation of a working atmosphere that makes teachers feel friendly, cooperative, and encouraging, based on which an environment conducive to teacher learning is formed [5]. On the basis of an employment relationship between the school and the teacher, the systems and activities developed by the school to promote the teacher's professional growth cover a wide range of support that emphasizes the importance of the teacher's personal development, respect for the teacher's opinions, and attention to the teacher's work experience, which is not only

[2] *Bandura A. Self-efficacy: toward a unifying theory of behavioral change. Psychological review, 1977, vol. 84, no. 2, pp. 191–215. DOI: 10.1037/0033-295X.84.2.191.*

reflected in the managerial level, but may also involve other broader areas. School support aims to promote teachers' professional growth, improve teaching quality and enhance job satisfaction. In this paper, school support mainly refers to emotional support, material support, institutional support and professional support. Emotional support refers to the support and assistance provided by schools to enhance teachers' sense of efficacy. Schools provide teachers with full spiritual and emotional support to help them relieve work pressure and enhance their sense of efficacy; material support refers to the comprehensive support provided by schools to enhance teachers' sense of efficacy to meet the needs of teachers' teaching, research, and personal development in order to promote the development of their sense of efficacy; and institutional support refers to the support provided by schools to promote the development of their sense of efficacy; and institutional support refers to the support provided by schools to promote the development of teachers' sense of efficacy. School institutional support refers to a series of scientific and systematic institutional guidelines established by the school to enhance teachers' sense of efficacy. Good institutional support can create a stable and orderly working environment for teachers, and has a positive orientation and guiding effect on teachers. School professional support refers to a series of targeted training programs that enable teachers to continuously refresh their professional knowledge and enhance their teaching abilities, thereby promoting their professional growth and professional improvement.

2. Self-efficacy theory

In 1977, the famous American psychologist A. Bandura has identified self-efficacy as a social cognitive theory[3]. It was not until 20 years later that A. Bandura provided a comprehensive and systematic treatment of self-efficacy. According to A. Bandura, self-efficacy is not a character trait that exists universally in everyone, but rather a sense of competence generated by the mutual intervention of the environment, the individual, and the behavior. This sense of competence specifically refers to a person's judgment of his or her ability to successfully complete a particular task in a particular situation. A. Bandura further distinguishes between two kinds of expectations: efficacy expectations and outcome expectations. Efficacy expectancies refer to beliefs about an individual's ability to take a certain action, while outcome expectancies refer to beliefs about whether an individual's behavior will produce a certain result[4].

The concept of teacher self-efficacy is actually derived and progressively developed from the basic idea of self-efficacy. It refers to teachers' confidence and beliefs about their ability to successfully perform teaching tasks in educational settings. Such beliefs affect not only teachers' teaching behaviors, but also their expectations and educational outcomes for their students. In short, teacher self-efficacy is a form of self-assessment and trust in teachers' ability to teach. Based on this, self-efficacy theory provides the theoretical underpinnings for this study and helps to provide insight into the impact of rural school support on teachers' self-efficacy, and it provides a framework for understanding how teachers in rural areas feel about their teaching abilities.

Between the 1970s and 1980s, A. Bandura's research focused mainly on self-efficacy. However, with the increasing interdependence of human social functioning and the importance of collective behavior, people began to pay more attention to and study collective efficacy, instead of limiting it to self-efficacy at the individual level. A. Bandura defined collective efficacy as "a shared belief among team members about the ability of their team to work together to achieve a particular level of performance in a given situation"[5]. Although teacher self-efficacy and teacher collective efficacy differ in their definitions and connotations, they both derive from social cognitive theory and reflect efficacy beliefs at the individual and group levels, respectively. Using self-efficacy as a theory, then, can help rural teachers increase their self-confidence and enhance their ability to face various challenges in educational work; in short, self-efficacy theory not only helps to analyze problems, but also provides practical tools for solving them.

Teacher efficacy refers to a teacher's perception of and belief in his or her ability to successfully carry out certain educational activities, and is a subjective judgment of a teacher's ability to positively influence students' learning and behavior, which is at the core of a teacher's beliefs about education [6]. Teacher efficacy encompasses both self-efficacy at the individual level and collective efficacy at the group level. In this paper, teacher efficacy is regarded as a holistic concept, which is a specific dimension of subordinate self-efficacy based on a group of teachers, focusing on the overall efficacy performance of a group of teachers. Teacher self-efficacy then refers to teachers' judgments and expectations about whether the teaching and research work activities they will engage in can be accomplished perfectly, and is a level of self-confidence in their ability to do their jobs [7]; teacher collective efficacy, on the other hand, refers to the perceptions of teachers in a school about the positive impact they, as a whole, can have on their students by working together [8]. A. Bandura defined teacher collective efficacy as "a shared belief among team members about their ability to work together as a team to achieve a particular level of performance in a given situation"[6]. The collective beliefs about teachers' ability to allocate, coordinate, and integrate relevant resources in order to collaboratively respond to a specific instructional task in a given context.

Based on this, this study takes the group of rural teachers in the rural environment as the research object, and pro-

[3] *Bandura A. Self-efficacy: toward a unifying theory of behavioral change. Psychological review, 1977, vol. 84, no. 2, pp. 191–215. DOI: 10.1037/0033-295X.84.2.191.*

[4] *Bandura A. Self-Efficacy: The Exercise of Control. New York, W.H. Freeman and Company Publ., 1997. 174 p.*

[5] *Bandura A. Social foundations of thought and action: a social cognitive theory. New Jersey, Prentice-Hall Publ., 1986. 648 p.*

[6] *See 5.*

poses the research hypothesis H1: Rural school support has a significant independent effect on teachers' sense of efficacy; the research hypothesis H2: Different levels of school support have different effects on teachers' sense of efficacy.

RESEARCH DESIGN

Research respondents

In order to better understand how rural school support affects teachers' sense of efficacy, this study researched rural school teachers in three districts in Heilongjiang Province.

Variable design

1. School support scale

The school support section is based on social support theory and comprehensively considers the dimensions of school support, which is categorized into four dimensions, namely emotional support, material support, institutional support, and professional support, with a total of 40 entries (Table 1). The scoring was based on a five-point Likert scale, with higher scores indicating more support provided by the school. In this study, the reliability of the school support scale was 0.986.

Table 1. *Description of school support scale entries*
Таблица 1. *Описание элементов шкалы школьной поддержки*

Column name	Number of cases	Minimum value	Maximum value	Mean value	Standard deviation
1. School leaders care about my teachers' professional development needs	2,069	1	5	1.89	1.027
2. School leaders are able to take a teacher's perspective when making decisions	2,069	1	5	1.98	1.090
3. When I work seriously, I can be recognized by my leaders	2,069	1	5	1.86	1.020
4. When I encounter difficulties in my work, I can get encouragement and help from the leaders	2,069	1	5	1.92	1.054
5. I can feel the leadership's attention, care and respect in my daily work	2,069	1	5	1.95	1.042
6. School leaders help and support me in my life	2,069	1	5	1.98	1.077
7. I can get support and help from my colleagues when I encounter difficulties in my teaching work	2,069	1	5	1.75	0.850
8. When I am depressed, I can get comfort and encouragement from my colleagues	2,069	1	5	1.80	0.879
9. When I encounter difficulties in my life, I can get help and care from my colleagues	2,069	1	5	1.79	0.885
10. I can get support and help from my colleagues when I do career planning for teachers	2,069	1	5	1.85	0.920
11. The school can provide sufficient funds for teachers' research and training	2,069	1	5	2.28	1.130
12. The school can provide sufficient funds for teachers' research	2,069	1	5	2.39	1.163
13. The school can provide teachers with the necessary resources (e. g. books, teaching aids, etc.) for work and study	2,069	1	5	2.09	1.037
14. The school has abundant hardware facilities and available resources	2,069	1	5	2.27	1.071
15. The school's network informationization infrastructure is complete	2,069	1	5	2.19	1.015
16. I am satisfied with the office conditions provided by the school	2,069	1	5	2.21	1.038

Continue of Table 1

Column name	Number of cases	Minimum value	Maximum value	Mean value	Standard deviation
17. The school is able to provide as much convenience for teachers' life as possible	2,069	1	5	2.21	1.076
18. The school has more performance pay for teachers	2,069	1	5	2.86	1.226
19. The school has established a teacher-apprentice teaming system	2,069	1	5	2.14	1.124
20. The school has set up a system for teachers to listen to and evaluate lessons	2,069	1	5	1.82	0.899
21. The school has established a teacher training system	2,069	1	5	1.84	0.914
22. The school has established a teacher research system	2,069	1	5	1.91	0.952
23. The school has established a teacher teaching and research system	2,069	1	5	1.87	0.925
24. Schools have established a democratic management system	2,069	1	5	2.06	1.067
25. The school has established a salary and welfare system	2,069	1	5	2.68	1.295
26. The school has established a complete performance appraisal program	2,069	1	5	2.32	1.181
27. The school has established a complete system of title promotion, selection and evaluation of excellence	2,069	1	5	2.16	1.106
28. The school has established a system to encourage teachers to cooperate and innovate	2,069	1	5	2.29	1.151
29. The school will carry out teaching skill competitions for teachers	2,069	1	5	1.93	0.945
30. The school arranges pre-service training for young teachers	2,069	1	5	1.92	0.962
31. The school regularly organizes teachers to participate in various professional trainings	2,069	1	5	1.90	0.930
32. The school organizes collective teaching and research activities for teachers	2,069	1	5	1.85	0.890
33. The school will organize teachers to participate in web-based training activities	2,069	1	5	1.70	0.825
34. The school has established an advanced school philosophy	2,069	1	5	1.90	0.943
35. The school has formed common values	2,069	1	5	1.94	0.977
36. The school has formulated inspiring and distinctive school development goals	2,069	1	5	1.99	1.024
37. Teachers have a group concept of mutual help and cooperation	2,069	1	5	1.91	0.934
38. Harmonious learning atmosphere is formed among teachers	2,069	1	5	1.89	0.925
39. Teachers in the same research group are able to carry out research and study on their own initiative	2,069	1	5	1.92	0.939
40. Teachers in the same teaching and research group will collectively sharpen and prepare for the teacher's open class	2,069	1	5	1.87	0.910

2. Teacher efficacy scale

Based on the understanding of self-efficacy theory and drawing on Goddard's Collective Efficacy Scale [9], the Teacher Efficacy Scale was compiled by combining the actual job satisfaction of rural teachers. The scale consists of two dimensions: two dimensions of teachers' collective efficacy and teachers' self-efficacy, with a total of 15 items (Table 2). Scoring was done on a five-point Likert scale, with higher scores indicating a higher sense of efficacy among teachers in the school. In this study, the reliability of the School Support Scale was 0.900.

Questionnaire quality

From the table of overall fitting coefficients (Table 3), it can be seen that CMIN/DF=5.273, RMSEA=0.045, SRMR=0.0404 results in good fit; CFI is 0.962, which is greater than 0.9, and results in good fit. Taken together, the model fit indices of the dimensions of the questionnaire and the overall structural model reached the recommended values, which not only indicates that the quality of the questionnaire is good, but also shows that the models of emotional support in rural schools, material support in rural schools, institutional support in rural schools, and professional support in rural schools are well adapted.

The factor loadings of each latent variable of emotional support, material support, institutional support, and professional support for rural school support corresponding to each topic in the questionnaire are all greater than 0.48, which indicates that each of its latent variables corresponding to the topic to which it belongs in the questionnaire

Table 2. *Description of teacher efficacy scale entries*
Таблица 2. *Описание элементов шкалы эффективности учителя*

Column name	Number of cases	Minimum value	Maximum value	Mean value	Standard deviation
1. School teachers are not absent on a daily basis	2,069	1	5	2.22	1.054
2. School teachers are generally satisfied with the school	2,069	1	5	2.07	0.996
3. Parents are satisfied with the school teachers (Teachers subjective perception of parents' feedback)	2,069	1	5	1.93	0.872
4. Teachers' classroom instruction meets students' learning needs	2,069	1	5	1.85	0.840
5. The overall quality of classroom teaching in the school is high	2,069	1	5	1.93	0.879
6. There are always good and bad students in a class, and teachers cannot teach every student to become good students	2,069	1	5	2.38	1.124
7. Generally speaking, what students become is innately determined	2,069	1	5	3.41	1.211
8. Generally speaking, what students become is determined by their families and society, and it is difficult to change them through education	2,069	1	5	3.29	1.212
9. The influence of teachers on students is less than the influence of parents	2,069	1	5	3.11	1.229
10. The extent to which a student can learn is mainly related to his family situation	2,069	1	5	2.97	1.153
11. If a student is unruly at home, he will not do well in school either	2,069	1	5	3.04	1.187
12. All things considered, the influence of teachers on a student's performance is very small	2,069	1	5	3.37	1.182
13. Even if a teacher is capable and enthusiastic, it is difficult for him to change many poor students at the same time	2,069	1	5	2.94	1.213
14. A good student can learn when you teach him, but a poor student can't be taught at all	2,069	1	5	3.39	1.196
15. Teachers can improve students' performance, but they can't do much to develop students' moral character	2,069	1	5	3.48	1.224

Table 3. *Table of overall fit coefficients*
Таблица 3. *Таблица общих индексов соответствия*

CMIN/DF	CFI	RMSEA	SRMR
5.273	0.962	0.045	0.0404

is highly representative. The variance AVE of each latent variable is greater than 0.66, and the CR of each latent variable is greater than 0.9 (see Table 4), which can be inferred that the convergent validity of this questionnaire is relatively satisfactory.

As can be seen from Table 5, the absolute value of the correlation coefficients of institutional support, professional support, material support, and emotional support in rural schools is less than the square root of the corresponding AVEs, i. e., it shows that the discriminant validity of the variable data is more satisfactory. Based on the reliability analysis above, it can be found that the reliability and validity of this questionnaire is better and the model fit between the variables is better, so it is suitable for distributing this questionnaire.

Methods

In order to better understand how rural school support affects teachers' sense of efficacy, this study was conducted on rural school teachers in three districts of Heilongjiang Province. The study was conducted on teachers' sense of efficacy in rural schools. A total of 2,539 questionnaires were distributed and 2,069 valid questionnaires were collected, with a validity rate of 81.5 %. This study used the software SPSS22.0 and AMOS26.0 to analyze and process the research data. By combing and analyzing the relevant literature in China and abroad, it was designed with rural school support as the independent variable and teacher efficacy as the dependent variable. The questionnaire was based on a Likert self-assessment 5-point scale, where 1 represents the lowest score and 5 represents the highest score. From 1 to 5, it corresponds to "Strongly Disagree", "Somewhat Disagree", "Neutral", "Somewhat Agree", and "Strongly Agree", respectively. A higher numerical value indicates greater school support and stronger teacher efficacy. The questionnaire has two components, the first part is the subjects' basic information, including the subjects' gender, age, education, marital status, school location, school of graduation of the first degree, type of specialization of the first degree (teacher-training vs. non-teacher-training),

Table 4. *The convergent effect among variables*
Таблица 4. *Конвергентный эффект среди переменных*

Factor loading / Teacher efficacy	AVE	CR
Emotional support	0.7200	0.9623
Material support	0.7012	0.9491
Institutional support	0.6996	0.9586
Professional support	0.8016	0.9798
Teachers' collective efficacy	0.7579	0.9390
Teacher self-efficacy	0.6676	0.9517

Note. The emotional support dimension is represented by questions 1 to 10 of the school support scale (see Table 1).
The physical support dimension is represented by questions 11 to 18 of the school support scale (see Table 1).
The institutional support dimension is represented by questions 19 to 28 from the school support scale (see Table 1).
The professional support dimension is represented by questions 29 to 40 from the school support scale (see Table 1).
The teachers collective effectiveness dimension is represented by questions 1 to 5 of the teacher effectiveness scale (see Table 2).
The teachers self-effectiveness dimension is represented by questions 6 to 15 of the teacher effectiveness scale (see Table 2).
Примечание. Измерение эмоциональной поддержки представлено вопросами 1–10 шкалы школьной поддержки (таблица 1).
Измерение физической поддержки представлено вопросами 11–18 шкалы школьной поддержки (таблица 1).
Измерение институциональной поддержки представлено вопросами 19–28 шкалы школьной поддержки (таблица 1).
Измерение профессиональной поддержки представлено вопросами 29–40 шкалы школьной поддержки (таблица 1).
Измерение коллективной эффективности учителей представлено вопросами 1–5 шкалы эффективности учителя (таблица 2).
Измерение самоэффективности учителей представлено вопросами 6–15 шкалы эффективности учителя (таблица 2).

Table 5. *Distinguishing validity among the four variables*
Таблица 5. *Разграничительная валидность среди четырех переменных*

Variable name	Institutional support	Professional support	Material support	Emotional support
Institutional support	0.814			
Professional support	0.689	0.684		
Material support	0.751	0.645	0.941	
Emotional support	0.638	0.557	0.675	0.750
Square root of AVE	0.902	0.827	0.970	0.866

Note. The diagonal is the value of AVE.
Примечание. По диагонали представлено значение AVE.

education level at the time of post-graduation employment, the section of the school they taught, the subject they taught, and the duration of their work in rural schools [10]. The second part is the main body of the questionnaire, the independent variable is rural school support, including school emotional support, material support, institutional support, and professional support; the dependent variable is teacher efficacy, including teacher self-efficacy, and teacher collective efficacy.

In order to gain a deeper understanding of the effects of subjects' different personal characteristics on teachers' sense of efficacy, this study used independent samples t-tests and one-way ANOVA methods, taking into account factors such as gender, marital status, majors studied, school location, graduation school, education level, sections taught, disciplines taught, and working hours, to discover the differences between teachers' sense of efficacy in the presence of subjects' different personal characteristics.

In order to better analyze the independent effects of rural school support and its elements on teachers' sense of efficacy, this study correlates rural school support, each element of support, and teachers' sense of efficacy, and analyzes whether or not there is a correlation between rural school support and its elements and teachers' sense of efficacy.

In order to investigate whether there is an independent effect of rural school support and the elements of rural school support on teachers' sense of efficacy, this study used linear regression analysis to put the elements of rural school support and rural school support into the regression equation to investigate the extent of their influence on teachers' sense of efficacy.

This study explores the effects of each element of rural school support on teachers' sense of efficacy by using stepwise multiple regression and putting each element of rural school support into the model at the same time. In the stepwise multiple regression model, teacher efficacy is taken as the dependent variable, and emotional support, material support, institutional support, and professional support in rural schools are taken as independent variables to analyze the effects of each element of rural school support on teacher efficacy.

RESULTS

Significant differences in teacher efficacy among teachers of different genders and school locations

The study found that there were significant differences in teacher efficacy among teachers of different genders, with female teachers having higher teacher efficacy than male teachers; there were no significant differences in teacher efficacy among teachers with different marital status; there were no significant differences in teacher efficacy among teachers with different specializations; there were significant differences in teacher efficacy among teachers with different school locations, with those in villages having higher teacher efficacy than those in towns and county; no significant difference in teacher efficacy among teachers from different graduation schools; no significant difference in teacher efficacy among teachers with different academic qualifications; no significant difference in teacher efficacy among teachers with different teaching periods; no significant difference in teacher efficacy among teachers with different teaching subjects; and no significant difference in teacher efficacy among teachers with different working hours. The specific results are shown in Table 6.

There is a significant correlation between rural school support and teachers' sense of efficacy

The results (Table 7) indicate that there is a significant correlation between teachers' sense of efficacy and emotional support in rural schools, material support in rural schools, institutional support in rural schools, and professional support in rural schools. The correlation coefficient between emotional support in rural schools and teachers' sense of efficacy is 0.194, the correlation coefficient between material support in rural schools and teachers' sense of efficacy is 0.225, the correlation coefficient between institutional support in rural schools and

Table 6. *Relationship between subjects' personal characteristics and teachers' sense of efficacy*
Таблица 6. *Взаимосвязь между личными характеристиками испытуемых и чувством эффективности учителя*

Personal Characteristics		***N***	**Average value**	**Standard deviation**	***F*/*T***	**Significance**
Gender	Male	572	2.68	0.731	*t*=−3.074 *P*=0.002	
	Female	1,497	2.79	0.712		
Marital status	Married	1,882	2.75	0.719	*t*=−1.308 *P*=0.191	
	Unmarried	187	2.82	0.725		
Specialization	Teacher training programs	1,703	2.75	0.716	*t*=−1.116 *P*=0.265	
	Non-Teacher training programs	366	2.80	0.732		
School location	County seat	402	2.70	0.739	*F*=4.360 *P*=0.013	
	Townships	1,342	2.76	0.719		
	Village	325	2.85	0.686		
Graduation school	985 University	4	2.08	0.877	*F*=1.656 *P*=0.175	
	211 University	9	3.02	0.543		
	General undergraduate colleges	445	2.77	0.742		
	Colleges and secondary schools	1,611	2.75	0.713		
Qualifications	Postgraduate and above	12	2.65	0.680	*F*=1.293 *P*=0.275	
	Undergraduate	818	2.72	0.755		
	Post-secondary	690	2.77	0.691		
	Secondary and below	549	2.79	0.700		
Sections taught	Elementary school	1,302	2.77	0.718	*F*=0.680 *P*=0.507	
	Middle school	740	2.75	0.723		
	High school	27	2.62	0.664		
Subjects taught	Major subject	974	2.73	0.709	*F*=1.531 *P*=0.217	
	Minor subject	894	2.78	0.720		
	Major + Minor	201	2.81	0.759		
Working hours	16+ years	1,357	2.73	0.707	*F*=2.164 *P*=0.055	
	13–15 years	62	2.75	0.728		
	10–12 years	66	2.63	0.825		
	7–9 years	68	2.74	0.795		
	4–6 years	299	2.85	0.686		
	0–3 years	217	2.83	0.767		

Table 7. *Correlation analysis between rural school support and teachers' sense of efficacy*
Таблица 7. *Корреляционный анализ между поддержкой в сельских школах и чувством эффективности учителей*

	M	SD	Teacher efficacy	Emotional support	Material support	Institutional support	Professional support
Teacher efficacy	2.76	0.719	–				
Emotional support	1.88	0.868	0.194**	–			
Material support	2.31	0.943	0.225**	0.762**	–		
Institutional support	2.11	0.913	0.262**	0.771**	0.808**	–	
Professional support	1.89	0.850	0.253**	0.768**	0.763**	0.877**	–

*Note. ** Significantly correlated at the 0.01 level (two-sided).*
*Примечание. ** Значимые корреляции на уровне 0,01 (двусторонний тест).*

teachers' sense of efficacy is 0.262, and the correlation coefficient between professional support in rural schools and teachers' sense of efficacy is 0.253. It can be concluded from the data of (Table 7) that the correlation between institutional support in rural schools and teacher efficacy to a greater extent, followed by professional support in rural schools.

Rural school support and its components have positive influence on teachers' sense of efficacy

Based on the above (Table 8), it is clear that rural school support and its various elements have a significant impact on teachers' sense of efficacy. The explanatory power of the effect of school support on teachers' sense of efficacy is 6.5 %. All the different elements of support in rural schools have an influence of more than 3 % on teachers' sense of efficacy, with institutional support in rural schools having the highest influence on teachers' sense of efficacy at 6.8 %, and affective support in rural schools being the lowest at 3.7 %. From (Table 8), it can be inferred that rural school support and its various elements have a positive and positive impact on teachers' sense of efficacy.

Rural school system support has the strongest impact on teacher sense of efficacy

The independent influence of each element of rural school support on teachers' sense of efficacy was analyzed above, while in reality rural school support cannot work alone. The results (Table 9) show that the tolerance values of the multiple regression model ranged from 0.232–1.000, and the VIF values ranged from 1.000–4.317, neither of which was greater than the value of the rubric. It is thus clear that there is no problem of multiple covariance between the independent variables that enter the regression equation.

As can be seen from the summary table of stepwise multiple regression analysis below (see Table 9), there are two variables with significant predictive power of the previous four predictor variables, namely, "institutional support" and "professional support". "Emotional support" and "material support" were excluded from the model because their explanatory power was too small.

In terms of the size of influence, the most influential variable on "teacher efficacy" is "institutional support", with an adjusted R^2 of 0.068; the second most influential variable is "professional support", with an adjusted R^2 of 0.070. "The standardized regression coefficients β of the two predictor variables in the regression model are 0.262 and 0.103 respectively, which are both positive, indicating that the influence of these two predictor variables on "teachers' sense of efficacy" is positive.

DISCUSSION

The relationship between rural school support and teacher efficacy

The subjective evaluation of teachers' competence and values demonstrated in the classroom has a direct impact on their effectiveness and professionalism. In rural school settings, teachers may face additional challenges and pressures due to resource and condition constraints. In fact, rural school support is one of the most important sources of teacher efficacy. When schools provide adequate support and assistance to teachers, teachers will feel more respect and trust, which will enhance their self-confidence and motivation. This positive state of mind will make teachers more actively involved in teaching, actively exploring new teaching methods and means to improve their teaching effectiveness. At the same time, these positive behaviors of teachers will also be recognized and affirmed by the school, which will further form a benign interactive cycle and promote the personal growth of teachers and the overall development of the school. Therefore, we can see that there is a mutual influence and mutual promotion between rural school support and teacher efficacy. In order to enhance rural teachers' sense of teacher efficacy, we need to provide more support and assistance from the school level; at the same time, teachers also need to actively face various challenges in teaching and continuously improve their profes-

Table 8. *Summary table of regression analysis of the effect of rural school support and its components on teachers' sense of efficacy*
Таблица 8. *Сводная таблица регрессионного анализа влияния поддержки в сельских школах и ее компонентов на чувство эффективности учителей*

Independent variable	R^2	F	β
School support	0.065	144.405	0.256
Emotional support	0.037	80.790	0.194
Material support	0.050	110.009	0.225
Institutional support	0.068	152.426	0.262
Professional support	0.064	141.932	0.253

Table 9. *Summary table of stepwise multiple regressions of rural school support and teacher efficacy*
Таблица 9. *Сводная таблица поэтапного множественного регрессионного анализа поддержки в сельских школах и эффективности учителей*

Input variables	Adjusted R^2	F-value	B	Standard error	β	Tolerance	VIF
Institutional support	0.068	152.426	0.206	0.017	0.262	1.000	1.000
Professional support	0.070	79.087	0.087	0.037	0.103	0.232	4.317

sionalism and teaching ability. It can be said that there is a mutually reinforcing relationship between rural school support and teacher efficacy.

Policy recommendations

Based on the above analysis, it was found that institutional support and professional support play a crucial role in enhancing teacher efficacy in rural school settings. Then, in order to further improve the sense of teacher efficacy in rural schools, the following suggestions are made:

1. Rural schools need to optimize the structure of the school support system and strengthen the teaching force

This study shows that a more comprehensive level of school support can enhance rural teachers' sense of efficacy to a large extent. Although the explanatory power of the effect of rural school support on teachers' sense of efficacy reached 6.5 %. However, rural school support did not act on teacher efficacy alone. Through correlation analysis, it was found that rural school institutional support and rural school professional support were associated with teacher efficacy to a greater extent; this was verified through regression analysis and found that rural school institutional support and rural school professional support positively predicted teacher efficacy. Therefore, schools should establish a systematic school support system centered on emotional, material, institutional, and professional support [11], so as to better enhance teacher efficacy.

In terms of emotional support in rural schools, schools should establish a good atmosphere of respect for teachers, understanding of teachers, give teachers more professional happiness and sense of belonging, which in turn enhances the teachers' beliefs and sense of mission to teach and educate people, and the enhancement of this intrinsic motivation will help teachers cope with the pressure of their work and life [12], and enhance the sense of teacher efficacy. At the same time, schools should pay attention to the emotional needs of teachers and provide teachers with good emotional value, for example, they can regularly organize teachers' symposiums, mental health lectures and other activities to help teachers alleviate work pressure and enhance stress resistance.

In terms of material support for rural schools, appropriate and reasonable economic support policies should be formulated to make up for the loss of rural teachers' interests arising from the spatial differences between urban and rural areas [13]. Schools should provide reasonable salaries and welfare benefits to ensure that teachers' labor is duly reported. Schools can also provide a comfortable working environment and improve teachers' office environment, such as providing spacious and bright offices, comfortable desks and chairs, and necessary office equipment, so that teachers can work in a comfortable environment, which can help to enhance their sense of teaching efficacy.

At the level of institutional support for rural schools, schools should do something to provide strong protection for the development of rural teachers, so schools should start from the two aspects of education and teaching and incentives and rewards to escort the development of teachers. At the level of professional support for rural schools, schools should have an in-depth understanding of the needs of teachers in order to provide accurate and powerful support for teachers. In addition to organizing various training activities to promote the professional development of teachers, schools should cooperate with local universities and educational research institutes to establish a teacher learning community in order to overcome professional isolation [14].

2. Rural schools need to improve institutional support to enhance teachers' sense of efficacy

Based on the above research findings, institutional support is a key factor in enhancing teachers' sense of efficacy. Specifically, the correlation coefficient between institutional support and teachers' sense of efficacy in rural schools is 0.262. Among all the support elements, the correlation coefficient of institutional support is the largest, which indicates that institutional support in rural schools is related to teachers' sense of efficacy to a greater extent, indicating that institutional support plays a key role in it, and that the explanatory power of the influence of institutional support on teachers' sense of efficacy in rural schools reaches 6.8 %, which is the largest compared with the other support elements. Compared with other support elements, institutional support in rural schools has the greatest influence on teachers' sense of efficacy. Therefore, rural schools need to make great efforts in building institutional support to ensure that teachers can feel more support and respect.

First, schools should develop a clear teaching management system to ensure that they have a clear and transparent teaching management system, including teaching programs, teaching assessment, and teaching feedback. Through the implementation of these systems, teachers can have a clear understanding of their teaching objectives and expectations, so that they can conduct their teaching activities in a more focused manner. Such clarity and transparency not only help to standardize teachers' teaching behaviors, but also allow teachers to find direction in the teaching process, thus enhancing their sense of teaching efficacy.

Second, establishing a fair and reasonable incentive mechanism is another important way to enhance teachers' sense of efficacy [15]. Schools set up a clear system of rewards and penalties to measure teachers' performance through a fair reward and punishment mechanism, and give recognition and rewards to teachers who have made outstanding achievements in teaching, which not only motivates teachers to continue to work hard, but also sets a role model for them, and stimulates teachers' enthusiasm and creativity. At the same time, teachers who are not performing well should be given appropriate guidance and assistance to help them improve.

Finally, the learning management should strengthen communication and exchange with teachers, understand their needs and expectations, and solve the problems they encounter in their work in a timely manner. This kind of communication and exchange not only enhances teachers' sense of participation and identification, but also helps them feel more supportive in their work. Through these measures, institutional support in rural schools will be improved and teachers' sense of efficacy will be enhanced.

3. Rural schools need to emphasize the role of professional support in teachers' sense of efficacy

In the context of the current education reform, professional support in rural schools is particularly important for enhancing teachers' sense of efficacy. Correlation analysis shows that professional support in rural schools is highly correlated with teachers' sense of efficacy, with a correlation coefficient of 0.253. Verification through regression analysis reveals that the explanatory power of the impact of institutional support on teachers' sense of efficacy in rural schools reaches 6.4 %, indicating that professional support in rural schools positively predicts teachers' sense of efficacy, further emphasizing the importance of professional support in the process.

In order to better achieve this goal in terms of professional support in rural schools, rural schools should take a series of specific measures. First, schools should organize regular professional training and refresher courses to ensure that teachers are able to update their educational philosophies and teaching methods [16]. These trainings should cover a wide range of aspects such as curriculum design, teaching methods, classroom management, and so on, to help teachers continuously improve their professional skills and knowledge in their teaching practice. Through these trainings, teachers can not only enhance their teaching ability, but also feel a greater sense of accomplishment and efficacy in the teaching process [17].

Secondly, schools should encourage teachers to participate in scientific research activities and provide necessary support for scientific research, such as research funds and time schedules. By participating in scientific research, teachers can continuously explore and discover new teaching concepts and methods, and improve their own scientific research ability and professionalism. At the same time, the school can also invite experts to review and guide teachers' scientific research results to help them better transform scientific research results into teaching practice. Again, schools should encourage teachers to carry out teaching innovation and try new teaching methods and strategies [18]. To this end, schools can set up a teaching innovation fund to recognize and reward teachers who have achieved remarkable results in teaching innovation, in order to stimulate teachers' enthusiasm for teaching innovation, and also to promote mutual schools and exchanges among teachers, forming a good atmosphere for teaching innovation [19].

Finally, schools should build communication platforms among teachers, such as teaching seminars and teaching experience sharing sessions. Through these platforms, teachers can share their teaching experience and insights, learn from each other and learn from the success of others. Through exchanges, teachers can not only improve their

own teaching level, but also enhance their teamwork spirit and sense of belonging, thus further improving their sense of teaching efficacy.

CONCLUSIONS

This study conducted research based on rural school teachers in three districts of Heilongjiang Province. Based on the research data, the study argued about the impact of rural school support on teachers' sense of efficacy. This study attempts to investigate whether rural school support affects teachers' sense of efficacy. It can be concluded from this study that rural school support has a significant effect on teachers' sense of efficacy, and the explanatory power of the effect of rural school support on teachers' sense of efficacy reaches 6.5 %. All the different elements of support in rural schools have an influence of 3 % or more on teacher efficacy. Institutional support in rural schools has significant positive predictive power on teachers' sense of efficacy. Teachers play a crucial role in education and teaching, and their hard work and selfless dedication lay a solid foundation for students' growth and development. Therefore, schools should not only ensure that teachers have professional teaching skills and organizational abilities, but also provide them with more support. Schools should provide teachers with a full range of support, such as emotional support, material support, institutional support, professional support, etc., in order to promote teachers to play a greater role in educational activities and contribute more to the growth and development of students. When schools provide support, the institutional and professional support they include has a positive and significant effect on teachers' sense of efficacy.

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Влияние поддержки в сельских школах на чувство эффективности учителей

Чжэнь Ин*[1,2,4], докторант факультета педагогики,
преподаватель Колледжа педагогических наук, научный руководитель магистрантов
Чжао Минь[2,5], магистрант, начальное образование, Колледж педагогических наук
Чэнь Си[3,6], преподаватель Школы марксизма
Чжэн Тинтин[2,7], магистрант, начальное образование, Колледж педагогических наук
[1]*Северо-Восточный педагогический университет, Чанчунь (Китай)*
[2]*Муданьцзянский педагогический университет, Муданьцзян (Китай)*
[3]*Муданьцзянский медицинский университет, Муданьцзян (Китай)*

***E-mail:** 2018023@mdjnu.edu.cn

[4]ORCID: https://orcid.org/0000-0002-1484-8139
[5]ORCID: https://orcid.org/0009-0007-8250-2918
[6]ORCID: https://orcid.org/0009-0006-9800-6364
[7]ORCID: https://orcid.org/0009-0006-2101-0832

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Аннотация: С целью изучения того, как поддержка в сельских школах влияет на чувство эффективности учителей и есть ли существенные различия во влиянии на него различных ситуаций поддержки, было проведено исследование в сельских школах в регионе провинции Хэйлунцзян. Оно показало, что: (1) существует значительная положительная корреляция между эффективностью учителей и поддержкой в сельских школах; (2) поддержка в сельских школах и ее элементы оказывают значительное независимое влияние на чувство эффективности учителей; (3) разные уровни поддержки в сельских школах оказывают различное воздействие на чувство эффективности учителей, а высокий уровень поддержки в школах оказывает большее влияние на чувство эффективности учителей. Для того чтобы усилить чувство эффективности сельских учителей, сельские школы, во-первых, должны оптимизировать организацию своей поддержки и укрепить структуру коллектива учителей; во-вторых, улучшить институциональную поддержку; в-третьих, обратить внимание на то, как профессиональная поддержка влияет на чувство эффективности учителей. Исходя из этого, повышение качества образования и обеспечение равенства в сфере образования могут быть достигнуты за счет повышения чувства эффективности учителей.

Ключевые слова: чувство эффективности учителей; поддержка школ; сельские школы.

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Processing of stimuli with hidden semantics by the cognitive unconscious

Aleksandr V. Banshchikov, assistant of Chair of General and Consulting Psychology,
assistant of Chair of General Psychology
St. Petersburg State Institute of Psychology and Social Work, St. Petersburg (Russia)
St. Petersburg State University, St. Petersburg (Russia)

E-mail: alex.bansh00@gmail.com ORCID: https://orcid.org/0000-0003-3719-9693

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Abstract: The debate about the capabilities and limitations of the cognitive unconscious continues since the term first appeared in scientific discourse. Researchers pay special attention to the processes of reading and related semantic processing, since it is typically believed that they occur exclusively consciously. Cognitive psychology has accumulated impressive empirical material that questions the current state of affairs. Studies in the paradigms of artificial grammar learning, word superiority effect, subliminal priming provide sufficient grounds to assume the ability of the cognitive unconscious to process semantic material. In the present experimental study, the author clarify the forms of manifestation of the cognitive unconscious when processing text material, namely, words written from right to left (inversions) and meaningless letter combinations. The participants perform a mnemonic task to recognize previously presented stimuli in a series of fillers. It is supposed that stimuli with a hidden semantic component – inverted words – will have an advantage in the speed and frequency of recognition, compared to meaningless letter combinations, and fillers will be recognized more slowly and less often than previously presented relevant stimuli. The desired effects were not detected, but a classic result for cognitive psychology is observed – correct answers are given faster than erroneous ones, and correct recognition of inverted stimuli occurs faster than all, which, albeit indirectly, indicates unconscious semantic processing. There are reasons to believe that the hypothesis could not be experimentally confirmed due to the use of the original research paradigm. The author plans a study using the classic subliminal priming paradigm to re-test the hypotheses put forward.

Keywords: cognitive unconscious; priming; word superiority effect; implicit learning.

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INTRODUCTION

The debate about the capabilities and limitations of the cognitive unconscious continues since the term was introduced into psychological science [1–3]. Some scientists reasonably believe that the capabilities of the cognitive unconscious are very limited, if not "primitive", and that the incredible results of unconscious processing of information are merely the result of poor experimental design or incorrect mathematical processing [4; 5]. J. Bargh, on the contrary, argues that many mental processes that we traditionally associate with consciousness occur much faster unconsciously, and that unconscious mental processes are the foundation of our everyday social life [6–8]. However, can opponents of the "intelligent unconscious" be accused of excessive skepticism? After all, if we agree that the unconscious works better and faster than consciousness, then it becomes unclear why we need consciousness in that case.

Phenomena and effects indicating the "intelligence" of the cognitive unconscious have been empirically recorded. A. Reber experimentally demonstrated that test participants can significantly distinguish between letter rows composed according to some pattern and random letter rows, even if they are unable to formulate verbally the rule by which the row is composed [9; 10]. The experimental paradigm he used was called Artificial Grammar Learning (AGL). This paradigm has been repeatedly tested experimentally, and in most studies, the effect has been successfully reproduced: depending on the complexity of the stimulus material, the probability of distinguishing "correct" rows varied from 47 to 75 % [11].

Note that the grammar of everyday language also represents a certain pattern: a grammatically ordered group of letters forms a word that is quickly and easily read by cognitive mechanisms, even when it is written with an error. J. Cattell studied this fact first and called it the word superiority effect (WSE) [12]. The effect is that people recognize letters faster and more accurately when they are presented in words, and not in meaningless sets of letters. Moreover, the effect extends further: words that are not connected are read twice as slowly as words that form sentences. When reading a coherent text, the entire process of perception occurs more effectively. What is surprising is that the fact of putting words together into sentences is

always given a posteriori; therefore, it is unclear how the described acceleration works.

There are a number of competing hypotheses claiming to explain the emergence of the word superiority effect; however, there is no doubt about the reality of the discovered phenomenon [13; 14].

It is interesting, but for a word to be processed by the cognitive system, it is not necessary to be aware of the fact of its presentation. A. Marcel demonstrated this convincingly in a series of sophisticated experiments that gave rise to the experimental paradigm of subliminal priming [15; 16]. It was shown that test subjects, as a rule, did not make mistakes when recognizing a word in a lexical decision task if this word was preceded (even if presented for only 10 ms!) by a semantically related prime. The developed experimental paradigm is considered classical and is actively used in research [17; 18]. Despite the fact that both the research procedure itself and the methods of mathematical analysis are subject to criticism, the priming paradigm remains one of the most frequently used [19–21].

Note that in the previously mentioned studies [9–12; 15–18], semantically loaded material was presented in accordance with the rules and norms of language, albeit with some noise that interfered with conscious processing. However, will the semantic material be read if these rules are violated? Note: not in the absence of any rules, but with an atypical presentation of words.

It was found that when presented with levidrome words – words that, when read backwards, form other meaningful words (for example, FLOW, WOLF; DEW, WED), test participants tend to read from right to left if the word is more frequent when spelled backwards [22]. Results indicating the unconscious reading of levidrome words from right to left were obtained by V.M. Allakhverdov together with L.E. Osipov: test participants read levidrome words significantly more slowly if they had previously encountered their reverse version [23].

However, will the cognitive unconscious process stimuli, which are assessed subjectively as meaningless, as meaningful words? It would seem that an insatiable urge to search for patterns and a special sensitivity to verbal stimuli should push towards such a result.

The present study is based on the theory of consciousness of V.M. Allakhverdov [24] as one of the most, in author's opinion, original and carrying heuristic potential. The derived by V.M. Allakhverdov's laws of the work of consciousness have both theoretical and empirical bases, which allowed including them in the psychological laws section as a very stable part of psychological reality[1]. It is these psychological laws that served as the basis for predicting the results of the work of the cognitive unconscious when processing stimuli with hidden semantics. Let us list some of them. James's law – unchangeable information is displaced from consciousness; Hume's law – random events are attributed to non-random causes; Freud – Festinger law – contradictory information is either displaced from consciousness or distorted, eliminating the contradiction.

To recognize a stimulus as previously presented, a standard must be stored in consciousness, with which the currently presented stimulus is compared. In order to store a stimulus as a standard, according to James's law, the stimulus must be modified, transformed. If a stimulus subjectively evaluated by the test participant as meaningless is presented, then, according to the Freud – Festinger law, this stimulus must either be changed or repressed from consciousness. But the presented stimulus must be stored, which means that work must be done to transform it. Consequently, the task of memorizing the stimulus becomes equivalent to the task of transforming it. This transformation will be aimed at giving the stimulus meaningful content, since, according to Hume's law, randomness is unthinkable by consciousness, therefore, the presented set of letters will be evaluated a priori as regular. V.M. Allakhverdov asserts that consciousness cannot stand nonsense, that is why it independently introduces regularity into the presented images [24]. It seems that this will be equally true for a row of letters, since the processing of text material begins with its visual perception, and in this, letters are no different from other images[2]. It turns out that the most available for search pattern in a letter row is grammatical ordering, and along with it, semantic loading.

The latter position is especially important, because it is well known, and in some ways even self-evident, that meaningful information is remembered better than meaningless information. A number of authors believe that memorization occurs due to the provision of a stimulus with semantic content[3]. Even the phenomenal memory of S.V. Shereshevsky is explained through the somatisation of the memorized, sometimes meaningless, material. It can be assumed that memorization and comprehension are identical phenomena.

Meaningful words are remembered better and recognized faster, which is obvious in itself, but if these effects are noticed on subjectively meaningless stimuli with hidden semantics, it can be argued that through the change that is necessary to store the stimulus, its semantic interpretation was found. If the hidden semantic component of the stimuli was not discovered during their transformation, then they will not have any advantage.

The purpose of the study is to clarify the forms of manifestation of the cognitive unconscious when processing text material.

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The following experimental hypotheses are put forward: 1) the cognitive unconscious significantly distinguishes relevant stimuli from irrelevant ones (fillers), which is expressed in the fact that relevant stimuli are (a) more often and (b) faster recognized than irrelevant ones; 2) the cognitive unconscious significantly distinguishes inverted words from a meaningless set of letters, which is expressed in the fact that inverted words will be (a) more often and (b) faster recognized compared to meaningless sets of letters.

METHODS

Sample

The study involved 112 people aged from 17 to 49 years (average age 24.65 years), including 49 men and 63 women. All participants had normal or corrected-to-normal vision and were native Russian speakers. Each participant was familiarized with the informed consent and gave voluntary consent to participate in the study with subsequent data processing. The proposed research hypotheses do not imply a more detailed collection of demographic data. Neither social status nor educational level are independent variables, since their significant influence on the obtained results is not initially assumed. General characteristics of mental processes are studied, which makes it appropriate to abstract from private and individual characteristics of the participants, moreover, these differences are taken into account in the mathematical model.

Stimulus material

Inverted words, i. e. words spelled backwards (for example, "privet" – "tevirp" (hello – olleh)), were chosen as stimulus material. The stimulus material was based on words of the Russian language included in the frequency dictionary[4], and was selected according to the following rules: 5 letters, 2 syllables, a consonant is always capitalized, letters in a word are not repeated.

Further, stimuli that in their inverted form resembled existing words were filtered. For example, the inversion of the word "zakon" – "nokaz" (law – wal) resembles the existing word "nakaz" (mandate), the inversion of the word "nomer" – "remon" (number – rebmun) resembles the existing word "remont" (repair, remount). It is known that words with a missing or one extra letter are highly likely to be read as a normal word due to the word superiority effect.

The phonetic complexity of the syllable makes it difficult to pronounce and perceive the stimulus[5]; therefore, stimuli forming in their inverted form phonemes that are atypical for the Russian language were selected. For example, the word "muzey" (museum) in its inverted form forms the unreadable "yesum".

Due to the presence of very strict parameters for selecting the stimulus material, it was not possible to match the selected words by frequency (ipm), but this parameter was taken into account in the mathematical model.

As a result, 12 nouns that underwent inversion were selected as target stimuli. 12 relevant – meaningless letter combinations were formed based on the selected nouns: the words were divided into syllables and mixed to form a meaningless letter combination corresponding to the previously specified parameters. 24 meaningless filler stimuli were created in the same way. Forming stimuli from the same syllables in different sequences was supposed to prevent their recognition by isolating smaller structural units (chunks), since for correct recognition it is necessary to preserve the entire stimulus.

Procedure

The study was conducted in person, in three stages, using a specially developed program based on LabJS.

The first stage is a demonstration of the stimulus series. In the experimental task, participants are asked to remember the presented letter rows (24 pcs., 12 – inverted words, 12 – meaningless letter combinations). The stimulus material is presented once, one after another, the demonstration time of each stimulus is 380 ms. There is a 36 ms break between stimuli so that the stimuli do not overlap. In this experiment, we refused to use a mask, since it additionally noisily interferes with the stimulus, and we assume that inversion is an analogue of noise that complicates the recognition of the stimulus as a meaningful word.

The second stage is a recognition task. 48 single stimuli, among which there are both relevant stimuli (inversion or nonsense) and fillers, are sequentially shown to participants. The participants are asked to decide whether they saw this stimulus at the demonstration stage or not.

The third stage is checking the awareness of the stimuli. After completing all the experimental tasks, the participants are informed that words were encrypted among the stimuli shown, and are asked whether they noticed this, and if so, they are asked to write down the words that were detected.

The presentation format is on the monitor screen, the decision on recognition of the stimulus is recorded by pressing the button for the corresponding answer. The time for making a decision is not limited, but the instructions ask to answer as soon as possible.

Statistical data processing

The jamovi program (version 2.5.3) was used for statistical analysis. The answer frequency analysis was performed in the program using a Generalized Mixed Model. The dependent variable was the participant's response (recognized – did not recognize), the factor was the stimulus type (inversion, nonsense or filler), the categorical dependent variable was logistic, and the cluster variables were individual differences in stimuli and test participants.

[4] *Lyashevskaya O.N., Sharov S.A. Frequency dictionary of the modern Russian language (based on the materials of Russian National Corpus). Moscow, Azbukovnik Publ., 2009. URL: http://dict.ruslang.ru/freq.php.*

[5] *Sarris M.E., Panagiotakopoulos C.T. Linguistic Effects on Anagram Solution: The Case of a Transparent Language. World Journal of Education, 2013, vol. 3, no. 4, pp. 41–51. DOI: 10.5430/wje.v3n4p41.*

The results for the time of making a decision on recognition were analyzed using a Mixed Model. Numerical values of time in milliseconds were subjected to logarithmation, and only logarithmic values were used in the model. Such a transformation makes the distribution closer to normal, softens the influence of extreme values and outliers, and helps to analyze relative changes in response time.

The selected statistical models are a more reliable analogue of ANOVA, which has proven its effectiveness in cognitive studies. It is assumed that the mixed model works primarily with normally distributed data, however, it is noted that violation of this rule does not usually lead to significant problems [25].

To minimize type I errors, the results were adjusted according to family-wise error control using the Holm multiple comparison method.

RESULTS

At the final stage of the experiment, the participants were informed that there were inverted words among the presented stimuli and were asked whether they noticed this. Only 7 of the 112 respondents were able to name meaningful words that were inverted, and they usually named no more than 2 out of 12 such words. It turns out that for the majority of respondents (94 %), inverted words were subjectively no different from a meaningless set of letters, and those respondents (6 %) who noticed the inversions were able to report no more than 2 words out of 12. The identified inversions were excluded from further analysis.

Statistically significant differences were found in the frequency of recognition of relevant stimuli and fillers (Fig. 1): relevant stimuli (63 %) are recognized significantly more often than false recognition of the filler (52.6 %) (p_{Holm}=0.009) occurs. The absolute difference in frequency appears to be insignificant, yet the participants show a consistent tendency to recognize relevant stimuli, which is consistent with the proposed hypothesis (1a).

Statistically significant differences were found in the frequency of recognition of inversions and fillers (Fig. 2): inversions (65.8 %) are recognized significantly more often than fillers (52.6 %) (p_{Holm}=0.022). However, no significant differences were found in the frequency of recognition of inversions and meaningless sets of letters (60.2 %) (p_{Holm}=0.335), as well as meaningless sets of letters and fillers (p_{Holm}=0.231), which contradicts the hypothesis (2a).

No statistically significant differences in response time were found for previously presented (relevant) stimuli and filler stimuli (Table 1): decisions on recognition of both types of stimuli were made at approximately the same rate (p_{Holm}=0.45). No significant differences in response time were found among inverted words and meaningless sets of letters (p_{Holm}=0.3), which contradicts the experimental hypotheses (1b and 2b).

At the same time, a result classical for experimental psychology was obtained: correct answers are given significantly faster than erroneous ones (Table 2). It means that respondents recognize relevant stimuli significantly faster than make an omission error (p_{Holm}<0.001); respondents erroneously recognize fillers significantly slower than make decisions about their correct non-recognition (p_{Holm}<0.001); respondents recognize inverted words significantly faster than make an omission error (p_{Holm}<0.001); respondents recognize meaningless sets of letters significantly faster than make an omission error (p_{Holm}<0.001). Moreover, statistically significantly less time is required to make the correct answer about recognizing an inverted word compared to a meaningless set of letters (p_{Holm}=0.003) and correct non-recognition of the filler (p_{Holm}<0.001). Apparently, inversions do have some advantage, albeit a very limited one.

DISCUSSION

According to the obtained results, our participants do not demonstrate unconscious differentiation between inverted words and meaningless sets of letters:

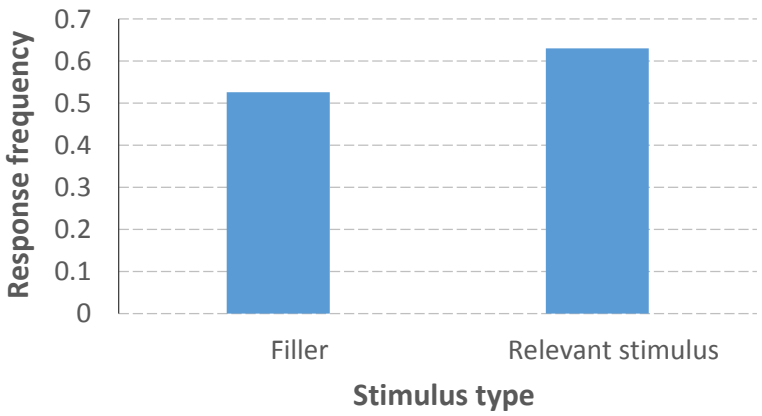

Fig. 1. *Average values of recognition of relevant stimuli and fillers*
Рис. 1. *Средние значения опознания релевантных стимулов и филлеров*

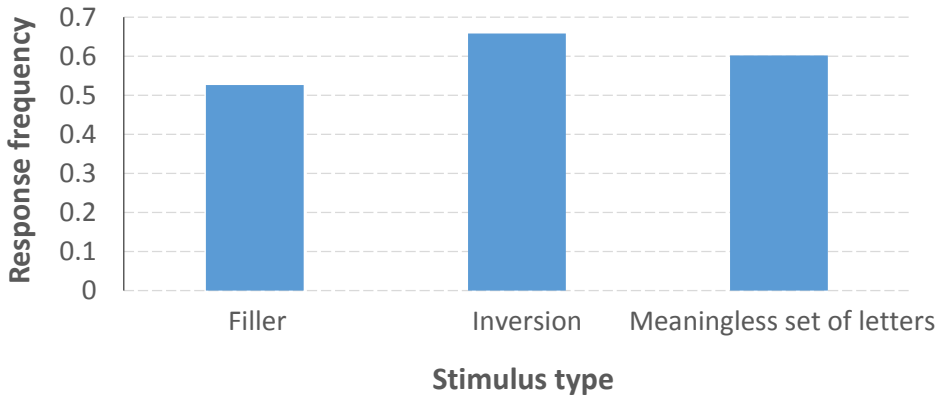

Fig. 2. *Average values of recognition of stimuli – inversions, meaningless sets of letters and fillers*
Рис. 2. *Средние значения опознания стимулов – инверсий, бессмысленных наборов букв и филлеров*

Table 1. *Average time of response to different types of stimuli, ms*
Таблица 1. *Среднее время ответа на разные типы стимулов, мс*

Stimulus type	Arithmetic average	Standard deviation
Relevant stimuli	1,150	838
Inversions	1,104	672
Meaningless sets of letters	1,195	974
Fillers	1,200	935

Table 2. *Average time to make correct and incorrect answers, ms*
Таблица 2. *Среднее время принятия верных и ошибочных ответов, мс*

Stimulus type	Answer type			
	Correct answer	Standard deviation	Erroneous answer	Standard deviation
Relevant stimuli	1,076	706	1,275	1,011
Inversions	1,016	503	1,274	890
Meaningless sets of letters	1,142	872	1,276	1,106
Fillers	1,145	976	1,248	894

no significant differences are observed in either the speed or frequency of recognition, which contradicts the proposed hypotheses (2a and 2b). However, it was found that the test participants significantly more often recognized previously presented stimuli (1a), and a result classical for cognitive psychology was also obtained – correct answers were given significantly faster than erroneous ones. Consequently, the respondents unconsciously distinguished between relevant stimuli and fillers, despite the fact that they subjectively assessed both types of stimuli as meaningless. This is possible only when imprinting and storing what was previously presented.

According to the previously introduced theoretical provisions, the storage of presented information is possible only when it is transformed, ordered and endowed with semantic content. Since the relevant stimuli were successfully recognized, these processes occurred.

Some test participants reported in the post-experimental interview that the stimuli presented to them evoked certain

associations that helped them memorize and subsequently recognize the stimulus. It is likely that the desired process of semantisation of meaningless material occurred, but took a different path than expected. This opens up the following possibility for interpretation: participants do not manifest a tendency to read unconsciously from right to left, the hidden semantic component is ignored, and the most adaptive strategy for memorizing meaningless material is to endow the stimulus with personal meaning. At the same time, if the participants could report it to us, then this process occurred consciously, which is contrary to the theory of the “smart” cognitive unconscious.

The results of this study cannot be interpreted either as a refutation of V.M. Allakhverdov’s theory or as evidence of the limited capabilities of the cognitive unconscious. Firstly, the alternative interpretation is argued against by the speed of stimulus material presentation – 380 ms, which is in the critical time window. This time is sufficient to see and read the stimulus, but not enough for a conscious search for an association, given that there are 24 such stimuli. It seems improbable that the obtained results indicate conscious semantisation. Secondly, it is also worth considering that when implementing an experimental study, there is a non-illusory chance to obtain a false negative result both due to the incorrect application of mathematical data processing methods and due to inaccuracies in the experimental design. It is likely that the obtained results may be associated with the original experimental paradigm, the “hidden pitfalls” of which have not yet been “polished” by many years of research experience. Further testing of the formulated hypotheses is planned using already established experimental paradigms.

CONCLUSIONS

1. Relevant stimuli are recognized significantly more often than fillers.

2. Inverted words are recognized significantly more often than fillers.

3. No significant differences were found between the recognition of inversions and meaningless sets of letters, either in speed or in frequency.

4. Correct answers are given significantly faster than incorrect ones.

5. Correct answers about recognizing inversions are given significantly faster than other correct answers.

6. Incorrect answers for all types of stimuli are given in the same time range.

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Обработка когнитивным бессознательным стимулов со скрытой семантикой

Банщиков Александр Витальевич, ассистент кафедры общей и консультативной психологии, ассистент кафедры общей психологии
Санкт-Петербургский государственный институт психологии и социальной работы, Санкт-Петербург (Россия)
Санкт-Петербургский государственный университет, Санкт-Петербург (Россия)

E-mail: alex.bansh00@gmail.com ORCID: https://orcid.org/0000-0003-3719-9693

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Аннотация: Дискуссии вокруг возможностей и ограничений когнитивного бессознательного не утихают с момента появления этого термина в научном дискурсе. Особое внимание исследователей уделяется процессу чтения и связанной с ним семантической обработке, так как хрестоматийно считается, что они происходят исключительно сознательно. Когнитивная психология накопила внушительный эмпирический материал, ставящий под сомнение сложившееся положение дел. Исследования в парадигмах artificial grammar learning, word superiority effect, subliminal priming (англ. «искусственное изучение грамматики», «эффект превосходства слов», «подпороговый прайминг») дают достаточно оснований предполагать способность когнитивного бессознательного к обработке семантического материала. В настоящем экспериментальном исследовании уточняются формы проявления когнитивного бессознательного при обработке текстового материала, а именно слов, написанных справа налево (инверсии), и бессмысленных буквенных сочетаний. Испытуемые выполняют мнемическую задачу на узнавание ранее предъявленных стимулов в череде филлеров. Предполагается, что стимулы со скрытой семантической составляющей – инвертированные слова – будут обладать преимуществом в скорости и частоте узнавания, по сравнению с бессмысленными буквенными сочетаниями, а филлеры будут узнаваться медленнее и реже, нежели ранее предъявленные, релевантные стимулы. Искомых эффектов обнаружено не было, однако наблюдается классический для когнитивной психологии результат: верные ответы даются быстрее ошибочных, а верные узнавания инвертированных стимулов происходят быстрее всех, что, пускай и косвенно, свидетельствует о бессознательной семантической обработке. Есть основания полагать, что гипотезы не удалось экспериментально подтвердить ввиду использования оригинальной исследовательской парадигмы. Планируется исследование с использованием классической парадигмы subliminal priming (англ. «подпороговый прайминг») для повторной проверки выдвинутых гипотез.

Ключевые слова: когнитивное бессознательное; прайминг; имплицитное научение.

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OUR AUTHORS

Banshchikov Aleksandr Vitalievich, assistant of Chair
of General and Consulting Psychology,
assistant of Chair of General Psychology.
Address 1: St. Petersburg State Institute of Psychology and Social Work,
199178, Russia, St. Petersburg, 12-th line of Vasilievsky Island, 13, building A.
Address 2: St. Petersburg State University,
199034, Russia, St. Petersburg, Universitetskaya Naberezhnaya, 7–9.
E-mail: alex.bansh00@gmail.com

Chen Xi, lecturer, School of Marxism.
Address: Mudanjiang Medical University,
157011, China, Mudanjiang, Tongxiang Street, 3.
E-mail: chenxi19911025@163.com

Ermoshkin Eduard Valerievich, senior lecturer
of Chair "Engineering and Computer Graphics".
Address 1: Siberian Transport University,
630049, Russia, Novosibirsk, Dusya Kovalchuk Street, 191.
Address 2: Novosibirsk State University
of Architecture and Civil Engineering (Sibstrin),
630008, Russia, Novosibirsk, Leningradskaya Street, 113.
E-mail: e.ermoshkin@sibstrin.ru

Pavlov Sergey Valerievich, postgraduate student.
Address: F.M. Dostoevskiy Russian Christian Academy of Humanities,
191023, Russia, St. Petersburg, Naberezhnaya Reki Fontanki, 15.
E-mail: pvlsergey@mail.ru

Petukhova Anna Viktorovna, PhD (Pedagogy), Associate Professor,
assistant professor of Chair "Graphics".
Address 1: Siberian Transport University,
630049, Russia, Novosibirsk, Dusya Kovalchuk Street, 191.
Address 2: Novosibirsk State University
of Architecture and Civil Engineering (Sibstrin),
630008, Russia, Novosibirsk, Leningradskaya Street, 113.
E-mail: petukhovaav@yandex.ru

Zhao Min, graduate student, Elementary Education,
College of Education Science.
Address: Mudanjiang Normal University,
157011, China, Mudanjiang, Wenhua Street, 19.
E-mail: zm13555527009@163.com

Zhen Ying, doctoral candidate, Faculty of Education,
lecturer of College of Education Science, tutor of master students.
Address 1: Northeast Normal University,
130024, China, Changchun, Renmin Street, 138.
Address 2: Mudanjiang Normal University,
157011, China, Mudanjiang, Wenhua Street, 19.
E-mail: 2018023@mdjnu.edu.cn

Zheng TingTing, graduate student, Elementary Education,
College of Education Science.
Address: Mudanjiang Normal University,
157011, China, Mudanjiang, Wenhua Street, 19.
E-mail: 995730454@qq.com

НАШИ АВТОРЫ

Банщиков Александр Витальевич, ассистент кафедры
общей и консультативной психологии,
ассистент кафедры общей психологии.
Адрес 1: Санкт-Петербургский государственный институт
психологии и социальной работы,
199178, Россия, г. Санкт-Петербург, 12-я линия В. О., 13, лит. А.
Адрес 2: Санкт-Петербургский государственный университет,
199034, Россия, г. Санкт-Петербург, Университетская наб., 7–9.
E-mail: alex.bansh00@gmail.com

Ермошкин Эдуард Валерьевич, старший преподаватель
кафедры «Инженерная и компьютерная графика».
Адрес 1: Сибирский государственный университет путей сообщения,
630049, Россия, г. Новосибирск, ул. Дуси Ковальчук, 191.
Адрес 2: Новосибирский государственный
архитектурно-строительный университет (Сибстрин),
630008, Россия, г. Новосибирск, ул. Ленинградская, 113.
E-mail: e.ermoshkin@sibstrin.ru

Павлов Сергей Валерьевич, аспирант.
Адрес: Русская христианская гуманитарная академия им. Ф.М. Достоевского,
191023, г. Россия, Санкт-Петербург, наб. реки Фонтанки, 15.
E-mail: pvlsergey@mail.ru

Петухова Анна Викторовна, кандидат педагогических наук, доцент,
доцент кафедры «Графика».
Адрес 1: Сибирский государственный университет путей сообщения,
630049, Россия, г. Новосибирск, ул. Дуси Ковальчук, 191.
Адрес 2: Новосибирский государственный
архитектурно-строительный университет (Сибстрин),
630008, Россия, г. Новосибирск, ул. Ленинградская, 113.
E-mail: petukhovaav@yandex.ru

Чжао Минь, магистрант, начальное образование,
Колледж педагогических наук.
Адрес: Муданьцзянский педагогический университет,
157011, Китай, г. Муданьцзян, ул. Вэньхуа, 19.
E-mail: zm13555527009@163.com

Чжэн Тинтин, магистрант, начальное образование,
Колледж педагогических наук.
Адрес: Муданьцзянский педагогический университет,
157011, Китай, г. Муданьцзян, ул. Вэньхуа, 19.
E-mail: 995730454@qq.com

Чжэнь Ин, докторант факультета педагогики,
преподаватель Колледжа педагогических наук,
научный руководитель магистрантов.
Адрес 1: Северо-Восточный педагогический университет,
130024, Китай, г. Чанчунь, ул. Жэньминь, 138.
Адрес 2: Муданьцзянский педагогический университет,
157011, Китай, г. Муданьцзян, ул. Вэньхуа, 19.
E-mail: 2018023@mdjnu.edu.cn

Чэнь Си, преподаватель Школы марксизма.
Адрес: Муданьцзянский медицинский университет,
157011, Китай, г. Муданьцзян, ул. Тунсян, 3.
E-mail: chenxi19911025@163.com

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