European Journal of Contemporary Education
E-ISSN 2305-6746
2022. 11(3): 718-726
DOI: 10.13187/ejced.2022.3.718
https://ejce.cherkasgu.press

Identification of the Research Potential of Students in the Process of Revealing Integrative Connections of the Subject Content of Mathematical Courses

Svetlana N. Dvoryatkina [a, *], Roman A. Melnikov [a], Vladimir E. Shcherbatykh [a]

[a] Bunin Yelets State University, Yelets, Russian Federation

Abstract

The existing array of scientific publications on modern methods, innovative forms and means of forming research abilities and skills solves this problem at the primary and secondary levels of education. The issues of identifying the research potential of students considered in the field of theory and methodology of vocational education (bachelor's degree), remain poorly studied. The purpose of the study is to develop and reveal the research potential of students in the process of teaching classical sections of mathematical science by defining a holistic integrative construct (using the example of a generalized function).

The assessment of the research potential of students in the process of revealing integrative connections of the subject content of mathematical courses was carried out on a sample of students of the 1-3 years of study in Applied Mathematics and Computer Science. The diagnostics was performed using the methodology of studying the research potential – the IP51 questionnaire (by N.V. Bordovskaya et al.). The empirical results of the study were analyzed using a set of mathematical and statistical methods (methods of descriptive statistics, Student's t-test).

The mechanisms of identifying the research potential in the process of revealing integrative connections of the subject content of mathematical courses are considered. The effectiveness of the inclusion of research tasks was proved by establishing significant differences in all components of the research potential between the control and experimental groups: in the cognitive component ($t = 16.11$, $p < 0.05$ and $p < 0.01$); in the motivational component ($t = 6.16$, $p < 0.05$ and $p < 0.01$ by behavioral component ($t = 11.64$, $p < 0.05$ and $p < 0.01$).

The results of the study have practical value, as they act as an effective mechanism for unlocking the research potential of students by setting special tasks to give integrity to the subject content of mathematical courses. The proposed research tasks for establishing integrative

* Corresponding author
E-mail addresses: sobdvor@yelets.lipetsk.ru (S.N. Dvoryatkina), roman_elets_08@mail.ru (R.A. Melnikov), wega18@mail.ru (V.E. Shcherbatykh)

connections in the content of mathematical courses have not been previously considered in the educational and methodological literature.

Keywords: research potential, integrative connections, integrative construct, mathematical disciplines, generalized functions.

1. Introduction

The identification of the research potential and further development of scientific research skills is the main goal of education at the level of secondary general and higher education in Russia, the United States, Great Britain, China and other countries (NRC, 2012; NGSS, 2013). Most Russian and foreign educational programs, as well as scientific and methodological research are aimed at helping students to form and develop their "research skills and abilities" (Askarov, 2017; Smirnova, 2018; Stadnik, 2013), "research potential" (Bordovskaia, 2017; Gruzina, 2021; Gunkov, 2014), "scientific reasoning skills" (Keys, 1994; Zimmerman, 2000), "scientific thinking" (Dunbar, 2000) or "skills of practicing scientists" (Roberts, 2002). Many scientific publications are devoted to the development of research abilities and skills at primary and secondary levels of education (Smirnova, 2018; Stadnik, 2013; Dvoryatkina, 2021), and there is an extensive methodological base at the master's and graduate levels (Safina, 2021; Dvoryatkina, Merenkova, 2021; Dunbar, 2000; Zimmerman, 2000). However, the studied on the strengthening the scientific and research component of undergraduate education are extremely limited. The available works are mainly focused on the formation of research abilities and skills of future teachers (Apazaova, 2009; Askarov, 2017; Fedoseeva, 2020), and only certain studies – in the conditions of engineering and mathematical education (Alisultanova, 2020; Bushueva, 2018; Jinhong, 2021). Indeed, according to the regulatory educational documents of Russia and Europe, the skills of educational research and project activities are mandatory requirements for the learning outcomes within the main educational program (Order, 2012; NRC, 2012; NGSS, 2013) at master's and postgraduate levels being the most important link in higher education, which recorded the status of a leading center for scientific research. It is at this stage that the interests of students are accumulated in the field of research activities, and the student himself acts as a young researcher. At the same time, the priority targets of scientific research in the field of theory and methodology of professional education (bachelor's level) are the formation of professional competencies of future specialists within the framework of leading educational activities. However, combining with research activities, the educational process is increasingly transformed into real professional activity, which currently serves the basis for the development of a competitive specialist.

Despite the fact that the problem of identifying the research potential of students in pedagogical science is not new, the issues of its regulation were updated as part of the federal projects of the Science national project. There is a need to rethink the existing methodological experience to identify effective didactic mechanisms thus enhancing the research potential of students who would effectively work in the context of the transformation of modern education.

The purpose of the study is to develop and unlock the research potential of students in the process of teaching classical sections of mathematical science by defining a holistic integrative construct (using the example of a generalized function).

2. Materials and methods

We believe that the research potential of students is their readiness for targeted, motivated research activities that ensure the success of the process of searching, acquiring and understanding new information; characterized by individual psychological characteristics of a person as a subject of this type of activity. Previously, the following characteristics were attributed to personalized parameters of the research potential: (1) tolerance to uncertainty, (1) tolerance to novelty, (2) motivation for results, (3) motivation for self-realization, (4) intellectual-cognitive activity, (5) need for intellectual activity, (6) critical and convergent thinking, (7) divergent productivity, (8) organization, perseverance and responsibility, (9) self-assessment of personal growth, (10) creative independence, (11) creative self-development, (12) scientific communication and dialogue (Dvoryatkina, Merenkova, 2021). Thus, the structural components of the research potential of students at the university are motivational (parameters 1-3), cognitive (parameters 4-7) and behavioral components (parameters 8-12).

The hypothesis of the study is that the development and disclosure of the research potential of youth in the process of teaching mathematics will be ensured if:

- integrative connections are established by identifying an integral integrative construct in the subject content of mathematical courses based on the principles of fundamentality, interdisciplinary, foundation, systemogenetics, information richness of the educational environment;
- the idea of the integrity of the subject content of mathematical courses is revealed through the corresponding organization of the student's research activities.

Research object: students of the 1-3 years of study in Applied Mathematics and Computer Science. In particular, the study was conducted from 2012 to 2021and involved 60 students of the Institute of Mathematics of Natural Science and Technology of Bunin Yelets State University from 17 to 20 years old, which is explained by the duration and variety of mathematical training courses. The pairwise selection method was used to select the respondents: from the general population the control and experimental groups were selected by the identity of neutral and control characteristics, and by the similarity of factor characteristics. As a result of selection, the experimental and control groups were equilibrated, each group consisting of 30 people. These groups were formed from students of the same area of training in Applied Mathematics, but from different training profiles. The selection included the distribution of students by faculty, i.e. the method of mechanical (systematic) selection. In the control group the mathematical disciplines were taught using traditional teaching methods, in the experimental group – the methodology for teaching higher mathematics was based on the introduction of research tasks into the educational process to establish integrative connections. When the control and experimental groups were formed the key requirements were the requirements of representativeness and homogeneity, which is important for the statistical processing of study results. An experimental design was applied with preliminary and final testing of both groups, which well controls the background effect and the effect of natural development.

Research subject: factors and conditions for identifying the research potential of students in the process of revealing the integrative connections of the subject content of mathematical courses.

A set of experimental research methods was used in the experiment: questionnaires, testing, expert methods. The empirical results of the study were analyzed using a set of mathematical and statistical methods (methods of descriptive statistics, Student's t-test). Tables, charts and graphs were used to visualize the experimental data. The parameters of the research potential were diagnosed using the method of studying the research potential – IP51 questionnaire (by N.V. Bordovskaya, S.N. Kostromina, S.I. Rozum, N.L. Moskvicheva, N.N. Iskra).

Didactic mechanisms for identifying the research potential of bachelor students

The integrative connections were found on the subject material of various mathematical courses performed by students within research tasks (projects) aimed at identifying a holistic integrative construct. If the subject material of, for example, a mathematical analysis course is structured and studied as some integrity, then hidden new empirical facts can be discovered. The integrity and internal unity of knowledge, the genesis of its structural elements ensure the development of the personality of a specialist in any professional field, forms the ability to quickly adapt to changing living conditions, reveal new problems and find their solutions, and competently work with information.

An example of such unity within the framework of mathematical training of students in the field of Applied Mathematics and Computer Science is an acquaintance with functions which properties go beyond the classical functions studied in the course of mathematical analysis. Such functions are commonly referred to as special functions.

Special functions traditionally include several classes of functions: integral functions (for example, Euler integrals of the first and second kind), orthogonal polynomials (for example, Legendre polynomials, Chebyshev polynomials, Ermit, Lagerre polynomials), cylindrical functions (Bessel functions, Hankel functions, Maclonald functions, etc.), elliptic functions, A.N. Krylov's functions, spherical functions, etc. A class of functions called the generalized functions holds a special place here. The simplest of the generalized functions is the pulsed delta function $\boldsymbol{\delta}(\mathbf{x})$, which was introduced into mathematics in the twenties of the twentieth century due to the efforts of the prominent English theoretical physicist, founder of quantum mechanics Paul Adrien

Maurice Dirac (Dirac, 1948). In the non-strict form it was everywhere defined as a function equal to zero, except for one point at which it took a value equal to infinity. At the same time, it has an interesting feature – an integral taken from it at any symmetric interval relative to zero, or on the entire real axis, is equal to one.

We believe that the first acquaintance of students of Applied Mathematics and Computer Science with the Dirac δ function is advisable within the framework of classical mathematical analysis. Since most of the properties of this function, one way or another, are associated with the concepts of "definite integral" and "improper integral", then immediately after studying the improper integrals, one of the lectures will be devoted to this function and its properties, paying special attention to the sifting property.

There are at least two approaches to defining this function by means of classical mathematical analysis. One of them is based on the idea of considering the δ function as the limit of a functional sequence with certain properties. The second approach relies on the concept of a needle-like function. In this case, it becomes possible to gradually continue to study the δ function in the process of research. Students receive their first research task within the framework of the Operational Calculus discipline.

Example of a research task on operational calculus. Study the relationship of the Dirac δ function with the Heaviside function. Get an image of the Laplace δ function.

Let us give some fragments of solutions to research tasks.

The key role in operational calculus plays the so-called Heaviside function (or inclusion function, or unit function).

There is a close connection between it and Dirac δ function. To establish it, the integral should be considered

$$\int_{-\infty}^{t} \delta(\theta)d\theta. \tag{1}$$

If t < 0, then the interval $(-\infty, t)$ does not contain points $\theta = 0$, and therefore, based on formula (6), the integral (1) will equal zero.

If t > 0, then the point $\theta = 0$ is within the interval $(-\infty, t)$ and, therefore,

$$\int_{-\infty}^{t} \delta(\theta)d\theta = 1. \tag{2}$$

So,

$$\int_{-\infty}^{t} \delta(\theta)d\theta = \begin{cases} 1, & t>0, \\ 0, & t<0. \end{cases} \tag{3}$$

Comparing formulas (3) and (1), we can conclude the following:

$$\int_{-\infty}^{t} \delta(\theta)d\theta = 1(t). \tag{4}$$

Formula (4) can be interpreted as follows: the Heaviside function is the primitive function of the Dirac δ function (or the δ function is the derivative of the Heaviside function).

Next, the Laplace transform for the Dirac δ function should be performed.

$$L[\delta(t)] = \int_{0}^{+\infty} \delta(t)\cdot e^{-pt}dt = e^{-pt}\Big|_{t=0} = e^{0} = 1. \tag{5}$$

Formula (5) again indicates that the Dirac δ function is an unusual function, so its Laplace expression equals one, which is not typical for classical original functions, because their Laplace expression should tend to zero.

Operational calculus makes it possible to obtain another important property of the Dirac δ function – its integral expression:

$$\delta(t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} e^{i\omega t}d\omega\ . \tag{6}$$

Next, we recommend moving on to the study of the applied aspects of the Dirac δ function in the theory of integral equations, ordinary differential equations, as well as in equations of mathematical physics.

Example of a research task on integral equations. Study the possibility of using the δ function for certain classes of integral equations. Give an example of its use in solving a specific integral equation.

In the theory of integral equations, equations of the below form

$$\int_0^x \frac{(x-t)^{n-1}}{(n-1)!} \cdot \varphi(t)\,dt = f(x), \quad (7)$$

related to the class of Volterra integral equations of the 1st kind, the convolutional type of equations, play a significant role.

Let us consider the integral equation of the form (7) putting $n = 2$, in the solution of which we will encounter the Dirac δ function:

$$\int_0^x (x-t)\cdot\varphi(t)\,dt = x .$$

The Laplace integral transform applies to both of its parts resulting in the following operator equation:

$$\frac{1}{p^2}\cdot\Phi(p) = \frac{1}{p^2} .$$

Obviously, it will be solved as follows

$$\Phi(p) = 1,$$

i.e. the expression of an unknown function $\varphi(x)$ is one, and as we know from formula (5) its original can only be $\delta(x)$. It turns out that $\varphi(x) = \delta(x)$, i.e. the solution of this integral equation will be the Dirac δ function.

Similar tasks can be proposed in other sections of higher mathematics, for example, in the theory of ordinary differential equations, in probability theory or equations of mathematical physics:

1. Study the relationship of the δ function with the Green's function when solving second-order linear differential equations. Give an example of using a δ function when solving a specific differential equation;
2. Study the question of the density of the discrete probability distribution based on the application of the Dirac δ function. Consider the possibility of determining the generalized density of the discrete random variable distribution.
3. Study the possibility of using the Dirac function and its derivatives in solving a problem of mathematical physics.

3. Results

The experimental verification of the hypothesis set in the study was carried out on key indicators of the research potential of bachelors in the process of studying mathematics in the control and experimental groups: the total score of the research potential, the severity of the motivational, cognitive and behavioral components. Given that these indicators were measured prior to experimental training and no differences were identified, let us provide numerical characteristics of the distribution of the student's research potential after experimental exposure (Table 1).

As the initial results of the study show, there are differences in all indicators between the control and experimental groups. Lower values were detected in the students of the control group, higher values – in bachelors of the experimental group. In particular, according to the motivational component of the research potential, there is a significant interest in the scientific search among the participants of the experimental group, however, a fairly large value of the standard deviation indicates an uneven formation of motivation for success among the participants in the experiment. This fact also confirms the positive excess in the experimental group, which indicates the intensity of excess in comparison with the normal distribution. The desire for scientific search among the study participants can also be realized in specific research achievements if there are other components, for example, in the motivation for success or in the motivation for self-realization, therefore, this requires further study.

Table 1. Distribution of the research potential of control and experimental groups after experimental training

Numerical characteristics	RP total score		Motivational component		Cognitive component		Behavioral component	
	Control group	Experimental group	Control group	Experimental group	Control group	Experimental group	Control group	Experimental group
Average	241.5	329	65.44	78.5	84.33	122.85	98.66	125.66
Standard deviation	18.03	9.67	7.12	10.86	6.83	10.70	9.77	9.99
Asymmetry	0.576	0.393	-0.37	-3.44	-1.86	-1.44	1.12	0.09
Excess	-0.39	-0.32	-0.49	14.45	4.77	2.09	1.27	-1.12

In the assessment of the cognitive component of the research potential, lower values were also noted in the students of the control group, and quite high – in the students of the experimental group. The obtained fairly high average values indicate the formation of research skills related to the successful solution of the set research problems, as well as the ability to intellectual creativity, the search for something new in the establishment of integrative connections. However, the standard deviation is also quite high.

The analysis of the behavioral component illustrates that it is quite high: the highest average score is observed in students of the experimental group, which is also explained by the larger proportion of research tasks, the lowest values are observed in students of the experimental group. The ability for operational self-organization and self-control in research activities, for its effective planning and load distribution were the result of experimental training.

There is a need to use a more effective Student's t-test for certain samples to identify statistical differences between the groups by the level of the studied indicator. The obtained statistical results are presented in Table 2.

Table 2. Check for statistical significance of mean RP values using the Student's t-test

Components	t	$t_{0.05;29}$	$t_{0.01;29}$	p-value
Motivational	6.16	2.04	2.76	$4.5 * 10^{-9}$
Cognitive	16.11	2.04	2.76	$1.09 * 10^{-15}$
Behavioral	11.64	2.04	2.76	$3.04 * 10^{-12}$
RP total score	22.59	2.04	2.76	$1.62 * 10^{-19}$
		$p < 0.05$	$p < 0.01$	

Significant differences were established between the control and experimental groups across all components. All this made it possible to reliably confirm that the identification of a holistic integrative construct in the subject content of mathematical courses had a positive impact on the level of development of all diagnosed indicators of the research potential.

4. Discussion

The application of the methodology for organizing research activities by setting specially selected tasks for establishing interdisciplinary ties solves the problem of ensuring the quality of mathematical education on the basis of the holistic, professionally demanded, integrative system of knowledge among students. Science states that the teaching of fundamental disciplines requires the use of the principles related to the search for the logical structure of mathematical theories, concepts that reveal the essence of mathematical knowledge, its foundations, origins, integrity. As an internal link in the study of mathematical courses, the authors recommend, for example, the use of the Dirac δ distribution. This distribution makes it possible to establish meaningful connections between various mathematical structures, to increase the level of scientific content of mathematics, generalization and systematicity of mathematical knowledge of students, understanding and assimilation of basic mathematical facts. The feasibility of introducing a new idea of the integrity of the mathematics can be justified as follows. First, the proposed approach will increase the level of fundamental mathematical training and improve the applied focus of the mathematics, which determines the main requirement currently imposed on graduates of higher educational institutions. Second, in the process of establishing and disclosing integrative connections of the subject content of mathematical courses, the research potential of students is updated. The novelty of the proposed non-standard research tasks is that they put students in a situation of active search for equally non-standard solutions, thus prompting the accumulation and integration of mathematical knowledge.

However, it should be noted that, first, the application of parametric statistics instead of non-parametric statistics, and second, the organization of experimental verification using control and experimental groups, can contribute to a decrease in the reliability of the obtained results. In the future, additional validation of the obtained results is required based on non-parametric statistics (Mann-Whitney U-test, Rosenbaum Q-test), as well as using a strategy for creating one experimental group and measuring the parameters of the research potential before and after training (Wilcoxon T-test).

5. Conclusion

Thus, the study allows making the following conclusions:

The modern concept of becoming a competitive specialist in the modern labor market is based on the actualization of such personal qualities and abilities as self-organization and expression, self-control and self-determination. The integration of elements of educational activity and scientific search, the harmonious construction of this synergy can become a mechanism not only for the intellectual, emotional-behavioral, motivational, but also for the professional development of students.

The effective development and disclosure of the research potential of students in the process of teaching mathematics is possible with the consistent organization of the educational process by including a holistic integrative construct in the subject content of mathematical courses based on the principles of fundamentality, interdisciplinary, foundation, systemogenetics, and information richness of the educational environment. The special functions studied in operational calculus, in the theory of ordinary differential integral equations, in the equations of mathematical physics and probability theory played the role of such an integrative construct.

The study proposed poorly studied research tasks in order to give integrity to the subject content of mathematical courses through the appropriate organization of the student's research activities to reveal this integrity.

In the future, it is possible to further study the applied capabilities of the Dirac function, expand the bank of research tasks (for example, when solving differential equations with a divergent argument, including with a delay in the argument). The study of some aspects may require special training, so there are opportunities to further consider this problem at the master's level.

References

Alisultanova, 2020 – *Alisultanova, E.D. Namaeva, M.M. Magamadova, T.S.* (2020). Metodologiya formirovaniya issledovatel'skoj kompetentnosti v usloviyah inzhenernogo obrazovaniya [Research competence formation methodology in the context of engineering education]. Vestnik GGNTU. *Gumanitarnye i social'no-ekonomicheskie nauki*. 4(22): 67-75. DOI: 10.34708/ГСТОУ.2020.78.28.009 [in Russian]

Apazaova, 2009 – *Apazaova, Z.N.* (2009). Formirovanie issledovatel'skih umenij i navykov u budushchih uchitelej tekhnologii metodom proektov [Formation of research skills among future technology teachers by the project method]. *Vestnik Adygejskogo gosudarstvennogo universiteta*. 1: 13-16. [in Russian]

Askarov, 2017 – *Askarov, I.B.* (2017). Upravlenie i planirovanie processom formirovaniya issledovatel'skih umenij i navykov budushchih prepodavatelej professional'nogo obrazovaniya [Management and planning process of formation research skills of future teachers of professional education]. *Shkola budushchego*. 2: 10-15. [in Russian]

Bordovskaia, 2017 – *Bordovskaia, N.V., Kostromina, S.N., Rosum, S.I., Moskvicheva, N.L.* (2017). Issledovatel'skij potencial studenta: soderzhanie konstrukta i metodika ego ocenki [Student's research potential: construct's content and method for its assessment]. *Psihologicheskij zhurnal*. 38(2): 89-103. [in Russian]

Bushueva, 2018 – *Bushueva, V.V., Bushuev, N.N., Bobrov, A.N., Samsonova, A.V.* (2018). Nekotorye aspekty podgotovki studentov MGTU im. Baumana k nauchno-issledovatel'skoj deyatel'nosti [Some aspects of training students of Bauman Moscow State Technical University for research activities]. *Gumanitarnyj vestnik*. 12(74): 6. [in Russian]

Dirac, 1948 – *Dirac, P.* (1948). The Principles of Quantum Mechanics. International Series of Monographs on Physics. Fourth Edition. OXFORD: Clarendon Press.

Dunbar, 2000 – *Dunbar, K.* (2000). How scientists think in the real world: Implications for science education. *Journal of Applied Developmental Psychology*. 21(1): 49-58.

Dvoryatkina, 2021 – *Dvoryatkina, S.N., Dyakina, A.A.* (2021). Horizontal Network Organization Form of Undergraduates' Research Activities Based on Interdisciplinary Interaction. International Conference on Language and Technology in the Interdisciplinary Paradigm (LATIP 2021). *European Proceedings of Social and Behavioural Sciences EpSBS*. 118: 575-583. DOI: 10.15405/epsbs.2021.12.71

Dvoryatkina, Merenkova, 2021 – *Dvoryatkina, S.N., Merenkova, V.S., Smirnov, E.I.* (2021). Diagnostics of psychological readiness of high school students for research activities in mathematics in the design context of a hybrid intellectual learning environment. *Perspectives of Science and Education*. 6(52): 192-210. DOI: 10.32744/pse.2021.6.13

Fedoseeva, 2020 – *Fedoseeva, L.A., Dubrovin, N.A., Ermolaeva, E.L., Vorontsov, A.M., Barsukova, A.E.* (2020). Issledovatel'skaya deyatel'nost' sovremennogo pedagoga [Research activity of a modern teacher]. *Sovremennye nauchnye issledovaniya i innovatsii*. 12(116): 41. [in Russian]

Gruzina, 2021 – *Gruzina, Y.M., Ponomareva, M.A., Prikhodko, L.V., Kharchilava K.P.* (2021). Creation of Effective Cooperation between Russia Youth and Foreign Higher Institutions in Research and Development Sphere. *European Journal of Contemporary Education*. 10(4): 924-942.

Gunkov, 2014 – *Gunkov, V.V.* (2014). Nauchno-issledovatel''skii potentsial studentov kak aktual'noe napravlenie razvitiya sistemy obrazovaniya v usloviyakh stanovleniya informatsionnogo obshchestva [Research potential students as the most current direction of education system in the formation of the information society]. *Vestnik Chelyabinskogo gosudarstvennogo pedagogicheskogo universiteta*. 4: 42-49. [in Russian]

Henry, 2021 – *Henry, J.R.* (2021). The Laplace transform. A Modern Introduction to Differential Equations (Third edition). Academic Press.

Jinhong, 2021 – Research on Further-Supporting Mechanism of Academic Science and Technology Competition Achievements for Science and Engineering Majors. *Advances in Applied Sociology*. 11: 482-491. DOI: 10.4236/aasoci.2021.1110042

Keys, 1994 – *Keys, C.W.* (1994). The development of scientific reasoning skills in conjunction with collaborative writing assignments: An interpretive study of six ninth-grade students. *Journal of Research in Science Teaching*. 3 (9): 1003-1022. DOI: 10.1002/tea.3660310912

NRC, 2012 – National Research Council (NRC). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. National Academies Press. 2012. [Electronic resource]. URL: https://www.nap.edu/catalog/13165/a-framework-for-k-12-science-education-practices-cross cutting-concepts

NGSS, 2013 – NGSS Lead States. Next generation science standards: For states, by states. National Academies Press. 2013. [Electronic resource]. URL: https://www.nap.edu/catalog/182 90/next-generation-sciencestandards-for-states-by-states

Order, 2012 – Order of the Ministry of Education and Science of Russia dated May 17, 2012 No. 413 (as amended on December 11, 2020) "On approval of the federal state educational standard of secondary general education" (Registered in the Ministry of Justice of Russia on June 7, 2012. №. 24480). [in Russian]

Roberts, 2002 – *Roberts, G.* (2002). SET for Success. The Supply of People with Science, Technology, Engineering and Mathematics Skills. HM Treasury, London.

Safina, 2021 – *Safina, G.G., Zakirova, V.G.* (2021). Razvitie motivatsionno-tsennostnogo otnosheniya magistrantov k samostoyatel'noi issledovatel'skoi deyatel'nosti [On the development of motivational and value attitude of undergraduates towards independent research activities]. *Mezhdunarodnyi nauchno-issledovatel'skii zhurnal*. 11-3 (113): 113-119. [in Russian]

Smirnova, 2018 – *Smirnova, P.V., Krivova, V.A.* (2018). Master-klass dlya starsheklassnikov: komu, zachem i kak nuzhno razvivat' issledovatel'skie navyki [Master class for high school students: who, why and how to develop research skills]. *Izvestiya instituta pedagogiki i psikhologii obrazovaniya*. 3: 107-115. [in Russian]

Stadnik, 2013 – *Stadnik, O.A.* (2013). Opyt formirovaniya issledovatel'skikh navykov uchashcheisya molodezhi putem uchastiya v konkursakh mezhdunarodnogo, vseukrainskogo i regional'nogo urovnei [Experience of research skills formation in young students by means of participation in competitions of international, all-ukrainian and regional levels]. *Nauchnyi dialog*. 8(20): 167-177. [in Russian]

Zimmerman, 2000 – *Zimmerman, C.* (2000). The development of scientific reasoning skills. *Developmental Review*. 20(1): 99-149. DOI: 10.1006/drev.1999.0497