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EVALUATION OF ADVANCED TECHNOLOGY FOR THE FORMATION OF RESEARCH COMPETENCE OF PHYSICS STUDENTS IN THE FIELD OF TRIBOLOGY

Abstract. The article examines the issues of determining the capabilities of the tribology laboratory workshop for the formation of research competencies, identifying the content, methods and tools of the tribology laboratory workshop that contribute to the formation of research competencies and systematization of diagnostics of the formation of research competencies of physics students. The aim of the research is to develop a methodology for the formation of research competencies of physics students, which contains interesting materials for a variety of forms of activity aimed at the formation and development of generalized and significant research skills for physics students. The authors propose one of the variants of the conditions for the formation of students' activities in practical classes on the physical foundations of tribology. To achieve the purpose of the study, we applied such methods of theoretical research as analysis and synthesis of scientific, pedagogical, methodological literature, observation, interviewing, questioning, conducting a pedagogical experiment, processing the results of a pedagogical experiment by methods of mathematical statistics. At different stages of the pedagogical experiment, 15 teachers and 437 physics students of the 3rd and 4th courses took part. As a result of the study, the structural composition and indicators of the formation of research competencies of physics students were identified, the methodology of mini-studies conducted within the framework of a laboratory workshop on the physical foundations of tribology was developed and implemented. The effectiveness of the developed methods of mini-studies conducted within the framework of a laboratory workshop in terms of the formation of research competencies of future physics specialists has been experimentally verified. The practical significance of the research is determined by the fact that its results provide a methodological basis and allows to significantly increase the possibilities of forming research competencies of future specialists by expanding the scope of tasks of the laboratory workshop on the basics of tribology and other profiling disciplines.

Key words: training, physical fundamentals of tribology, future specialists, professional competence, design and research activities, practical work.

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ТРИБОЛОГИЯ САЛАСЫНДАҒЫ ФИЗИК СТУДЕНТТЕРДІҢ ЗЕРТТЕУ ҚҰЗЫРЕТТІЛІКТЕРІН ҚАЛЫПТАСТЫРУДЫҢ ОЗЫҚ ТЕХНОЛОГИЯЛАРЫН БАҒАЛАУ

Аннотация. Мақалада зерттеу құзыреттіліктерін қалыптастыру үшін трибология бойынша зертханалық практикумның мүмкіндіктерін анықтау, зерттеу құзыреттіліктерін қалыптастыруға және физик студенттердің зерттеу құзыреттіліктерінің қалыптасуын диагностикалауды жүйелеуге ықпал ететін трибология бойынша зертханалық практикумның мазмұнын, әдістемесі мен құралдарын анықтау мәселелері зерттелді. Зерттеудің мақсаты физик студенттер үшін жалпыланған және маңызды зерттеу дағдыларын қалыптастыруға және дамытуға бағытталған қызмет түрлерінің алуан түрлілігі үшін қызықты материалдарды қамтитын физик студенттердің зерттеу құзыреттіліктерін қалыптастыру әдістемесін әзірлеу болып табылады. Авторлар трибологияның физикалық негіздері бойынша практикалық сабақтарда студенттердің іс-әрекетін қалыптастыру шарттарының бір нұсқасын ұсынды.

Зерттеу мақсатына жету үшін ғылыми-педагогикалық, әдістемелік әдебиеттерді талдау және синтездеу, бақылау, сұхбат беру, сауалнама жүргізу, педагогикалық эксперимент жүргізу, математикалық статистика әдістерімен педагогикалық эксперимент нәтижелерін өңдеу сияқты теориялық зерттеу әдістері қолданылды. Педагогикалық эксперименттің әртүрлі кезеңдеріне 15 оқытушы және 437 физик 3 және 4-курс студенттері қатысты. Зерттеу нәтижесінде физик студенттердің зерттеу құзыреттіліктерінің құрылымдық құрамы мен қалыптасу көрсеткіштері анықталды, трибологияның физикалық негіздері бойынша зертханалық практикум шеңберінде жүргізілетін шағын зерттеулердің әдістемесі әзірленді және енгізілді. Болашақ физика мамандарының зерттеу құзыреттерін қалыптастыру бөлігінде зертханалық практикум шеңберінде жүргізілетін мини-зерттеулердің әзірленген әдістемелерінің тиімділігі эксперименталды түрде тексерілді. Зерттеудің практикалық маңыздылығы оның нәтижелері әдіснамалық негізді қамтамасыз ететіндігімен және трибология және басқа да бейіндік пәндер негіздері бойынша зертханалық практикум тапсырмаларының тақырыбын кеңейту арқылы болашақ мамандардың зерттеу құзыреттерін қалыптастыру мүмкіндіктерін едәуір арттыруға мүмкіндік беретіндігімен анықталады.

Түйін сөздер: оқыту, трибологияның физикалық негіздері, болашақ мамандар, кәсіби құзыреттілік, жобалау-зерттеу қызметі, практикалық жұмыс.

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ОЦЕНКА ПЕРЕДОВЫХ ТЕХНОЛОГИЙ ФОРМИРОВАНИЯ ИССЛЕДОВАТЕЛЬСКИХ КОМПЕТЕНЦИЙ СТУДЕНТОВ-ФИЗИКОВ В ОБЛАСТИ ТРИБОЛОГИИ

Аннотация. В статье исследованы вопросы определения возможностей лабораторного практикума по трибологии для формирования исследовательских компетенций, выявлении содержания, методики и средств лабораторного практикума по трибологии, способствующие формированию исследовательских компетенций и систематизации диагностики сформированности исследовательских компетенций студентов-физиков. Целью исследования является разработка методики формирования исследовательских компетенций студентов-физиков, которая содержит интересные материалы для разнообразия форм деятельности, направленных на формирование и развитие обобщенных и значимых для студентов-физиков исследовательских умений. Авторами предложен один из вариантов условия формирования деятельности студентов на практических занятиях по физическим основам трибологии.

Для достижения цели исследования нами были применены такие методы теоретического исследования, как анализ и синтез научно-педагогической, методической литературы, наблюдение, интервьюирование, анкетирование, проведение педагогического эксперимента, обработка результатов педагогического эксперимента методами математической статистики. На разных этапах педагогического эксперимента приняли участие 15 преподавателей и 437 студентов-физиков 3 и 4 курсов. В результате исследования выявлены структурный состав и показатели сформированности исследовательских компетенций студентов-физиков, разработана и внедрена методика мини исследований, проводимых в рамках лабораторного практикума по физическим основам трибологии. Экспериментально проверена эффективность разработанных методик мини исследований, проводимых в рамках лабораторного практикума, в части формирования исследовательских компетенций будущих специалистов физики. Практическая значимость исследования определяется тем, что его результаты обеспечивают методологическую основу и позволяет существенно увеличить возможности формирования исследовательских компетенций будущих специалистов путем расширения тематики заданий лабораторного практикума по основам трибологии и других профиллирующих дисциплин.

Ключевые слова: обучение, физические основы трибологии, будущие специалисты, профессиональная компетентность, проектно-исследовательская деятельность, практическая работа.

Introduction. Currently, one of the main goals of higher education is the professional and personal development of a specialist and the development of his competitiveness as a competent specialist (Boiko, 2021). Achieving this goal will allow an individual to successfully solve the problems of employment, professional adaptation, socialization in the conditions of the growth of knowledge-intensive industries. However, teaching physics to students at universities today has no theoretical justification from the point of view of education focused on the industrial and technical sphere. In particular, the issues of the need to train future physicists in the field of tribology and the formation of their professional competencies in this field have not been resolved.

The concept of tribology is found in all spheres of our life. That is, tribology is a science that studies and describes contact interaction in the relative motion of highly deformable bodies, one of the specific areas of physics (Bharat Bhushan 2013).

Tribophysics as a branch of modern physics studies the processes and phenomena occurring in real systems of bodies (tribosystems), where bodies contact each other in conditions of mutual displacement. Tribophysics considers problems of thermodynamics, statistical physics, electrodynamics, kinetics and others that go beyond mechanics and materials science. The current stage of development of tribophysics is characterized by a comprehensive approach to the study and cognition of phenomena of processes occurring on surfaces and in the surface layers of interacting bodies, the use of highly effective physical, chemical and mathematical research methods and computer technology (CRC Press, 2020).

Analysis of the results of experimental and theoretical studies has made it possible to achieve significant progress in understanding the nature of friction and wear of various materials under various external conditions and different states of interacting surfaces (Bougoffa et al., 2021; Guo et al., 2022).

Disciplines on tribology for physics students should be considered as interdisciplinary, innovative in nature, which aims the graduate to solve modern and advanced problems of quality development and enhanced properties of modern technical systems, for example, when performing final qualifying work, as well as in further professional activity. The study of such disciplines aims to assimilate students' knowledge of the basics of tribology and tribotechnics so that in practical work they can assign measures to ensure the durability of friction units of machines and equipment at the design, manufacture and operation stage. To achieve this goal, a competence-based approach occupies a special place in training.

Today, the urgent task of world education is to improve the quality of education, both general and professional. To solve this problem, the goals and results of education are being rethought, its content is changing and the concept of "professional competence" is being increasingly used (Bienzobas & Barderas, 2010; Antera, 2021), which includes such concepts as "qualification", "professionalism", "professional readiness", etc. The purpose of the competence approach is to establish a correspondence between the knowledge and skills acquired by university graduates and the requirements for professional qualities imposed by the labor market, smoothing the difference between educational and professional activities (Keinänen & Kairisto-Mertanen, 2019).

There are several definitions of the concept of competence, which formed the basis of our research. For example, Al jamal, Prabhakar, Saleem, Farley, (2019) defines competence as the ability to successfully respond to individual or societal requirements or perform a task. Knyazev, (2021) believes that competence is an alienated, predetermined requirement for human training. It includes a set of interrelated personality qualities (knowledge, skills, skills, ways of activity), set in relation to a certain range of subjects and processes and necessary for high-quality productive activity in relation to them.

Despite the constant growth of publications devoted to the development of the competence approach in education, the degree of development of this problem in the field of teaching natural sciences, in particular physics, is low. There are still discrepancies in the concept of "competence" and there is also no unified diagnostic system for the formation of certain competencies and the methodology for their formation. Despite a number of works devoted to the analysis of the formation of students' competencies (Tsvetkova M., Saenko N., Levina V., Kondratenko L. & Khimmataliev D., 2021); this issue is far from being resolved.

Our research is aimed at the formation of research competencies, since the organization of the educational process, during which the student would have the ability to explore emerging problems of various kinds, is an important pedagogical task. These skills are formed in the university during the educational and research work of students. When performing educational research, students learn to independently conduct experiments of one kind or another, apply their knowledge in solving specific scientific problems. Since the experiment is a very important and integral part of teaching physics, the presence of research skills among physics students is a prerequisite for their high professionalism. In this regard, the problem of forming the research competence of physics students becomes urgent. Therefore, it is necessary to analyze the concept of "research competence", interpreted by scientists in different ways. Garay-Argandona, Rodriguez-Vargas, Hernandez, Carranza-Esteban, Tuero, (2021) research competence means the ability and research skills related to the analysis and evaluation of scientific material. Tastanbekova, Abenova, Yessekeshova, Sagaliyeva, Abildina, (2021) in her research built a model for the formation of students' research competence, which she based on research competence as a component of value-semantic, personal self-improvement, social and labor, educational and cognitive, general cultural, informational, communicative competencies.

Analyzing the above, we can conclude that there are contradictions between the need for future specialists capable of solving new professional tasks and an insufficiently developed system of preparation for their solution. Thus, the "research competence" in this study is understood as a combination of special human qualities with research and skills, allowing the student to perform laboratory practice at a high level.

Onipko & Sherstiuk, (2020); Anti, Kuswanto, Mundilarto, Rosa, (2019); Cheng, Tong & Tai, (2022); Bakhytkul, (2018) and other scientists have proposed methods for the formation of research skills in the framework of a laboratory workshop. A number of works are devoted to the methodology of organizing educational and research activities during laboratory work as a form of quasi-professional activity, including the use of "non-standard" materials.

Despite the considerable interest of researchers in the forms of organization and content of the laboratory workshop in physics, the question of its implementation in the courses has not been studied enough. The study of the process of teaching physics in higher school, the survey of students of VSU and MKTU teachers and their own experience of pedagogical activity allowed to reveal contradictions between:

- the need for high-quality training of future specialists to solve the problems of research activities and underestimation of the possibilities of forming their research competencies not only in courses, in particular, in the framework of a laboratory workshop on tribology;

- the potential possibilities of the tribology laboratory workshop and the insufficient development of its content and methodology for the formation of research of each physics student;

- the need to diagnose the formation of research competencies of physics students and the uncertainty of their structural composition.

Thus, the problem of research is to find the answer to the questions:

- what are the possibilities of a laboratory workshop in general physics for the formation of research competencies of physics students in junior courses?

- what are the contents, methods and means of a laboratory workshop in general physics that contribute to the formation of research competencies for all undergraduate physics students?

- what should be the diagnosis of the formation of research competencies of a physics student?

Methods and materials. The following methods were used in the course of the research: analytical and synthetic consideration of philosophical, psychological, pedagogical, methodological literature, dissertations, scientific publications and normative documents devoted to the problem of research; observation, interviewing, questioning, generalization of positive teaching experience; modeling of the educational process, abstraction; pedagogical experiment; processing of the results of pedagogical experiment by methods of mathematical statistics; method of reconstruction of pedagogical experience; analysis and generalization of experimental work.

The study of the problem was carried out in three stages: The ascertaining pedagogical experiment at the educational institution "International Kazakh-Turkish University named after H.A. Yassavi" and "East Kazakhstan University named after S. Amanzholov" was aimed at determining the level of formation of research competencies of physics students at different levels of education, as well as the search for means and methods to increase the level of formation of research competencies of junior physics students. At different stages, 15 teachers and 437 physics students of the 3rd and 4th courses took part in the pedagogical experiment.

During the ascertaining experiment, the following tasks were solved: determining the level of formation of research competencies of future physics teachers; determining the degree of readiness of senior students for independent research work. When conducting a ascertaining pedagogical experiment, the following methods were mainly used: attending laboratory practice classes and specialization disciplines, talking with leading teachers, questioning teachers and students, filling out diagnostic cards and student self-development cards, conducting control sections.

The search pedagogical experiment was carried out in order to clarify the hypothesis put forward, to select effective methods, forms, means of forming research competencies and to search for optimal diagnostics of research competencies.

During the search experiment, the following tasks were solved:

- approbation and verification of the developed creative tasks for mini-studies, clarification of the methodology and technique of their implementation;

- selection and verification of the effectiveness of diagnostics of the formation of various levels of research competencies;

The level of formation of students' research competencies was determined by the results of a series of control sections, questionnaire analysis, and evaluation of special seminars.

The next stage of our research was a formative pedagogical experiment, the purpose of which was to confirm the hypothesis of the study.

The experiment lasted four years: from 2018 to 2021.

During the formative experiment, the following task was solved: to test the effectiveness of the developed methodology for the formation of research competencies of undergraduate physics students in the framework of a laboratory workshop (using mini-studies).

The levels of formation of research competencies of undergraduate physics students were determined by the results of a series of control sections, questionnaires, seminars, analysis of diagnostic charts.

Results. Within the framework of our research, based on the study of the practical side of the problem under consideration, 4 main components of the professional research activity of a bachelor of physics are identified: planning and organizational; diagnostic and prognostic; inventive and rationalizing; experimental and measuring. The analysis of psychological and pedagogical literature and the selected components made it possible to systematize the research competencies of the Bachelor of Physics (Figure 1).

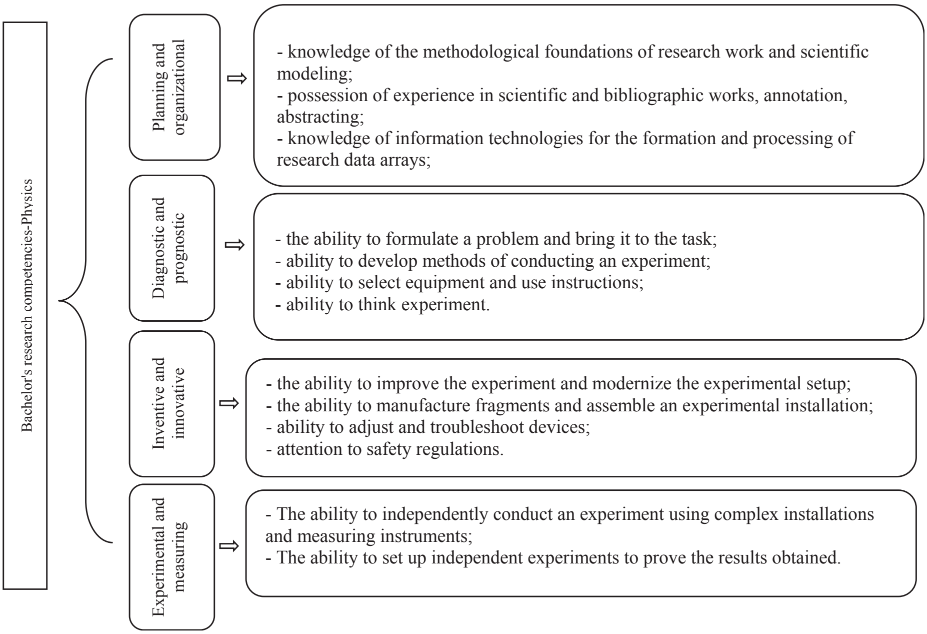

Figure 1. Bachelor's research competencies-Physics

The educational program of higher professional education highlights general cultural (OK) and professional competencies (PC), which must be formed by bachelors in the direction of 6B01510 and 6B05348 - physics.

When starting to study the research competencies of physics students, we took into account that by this time a certain level of research competencies had already been formed at school and in the first year of the university. The measurement of this level, as well as its change during the pedagogical experiment, must be carried out on the basis of established indicators. It turned out to be rational to distinguish three levels of formation of research competencies: "low", "medium", and "high". The indicators on the basis of which it is possible to determine the levels of formation of research competencies are presented in Table 1.

Table 1 – The level of formation of research competencies

Indicators	The level of formation of research competencies		
	Low	Medium	High
positive motivation for research activities in the field of tribology	occupation by necessity, without interest	manifestation of unstable interest	manifestation of active interest, turning into a hobby
sustained interest in working with scientific sources of information on the physical foundations of tribology	lack of independent interest in sources containing scientific information; work with the proposed scientific information	manifestation of unstable interest in sources of scientific information; search for necessary information with some help	showing a steady interest in sources of scientific information; independent search for necessary information
activity in the search and solution of research problems of tribology	conducting research and solving research problems under the guidance of a teacher	conducting research and solving research problems with the partial assistance of a teacher	conducting research and solving research problems independently
conscious and rational implementation of the stages of research activity on the physical foundations of tribology	the sequence is chaotic, not rational	the sequence is not well thought out	performing all operations consistently, thoughtfully, rationally
Competent analysis of the results of laboratory work in the course of tribological processes	lack of analysis of the solution and the result obtained	a superficial analysis of the solution and the result obtained	in-depth analysis of the solution and the result obtained
Perseverance when performing operations with installations in the laboratory	the search for a solution can easily be interrupted	finding the only solution, inability to find an alternative solution	dissatisfaction with the result obtained, search for new solutions
competent and logical presentation and protection of the results obtained in determining the tribological characteristics of materials	presentation and protection of the obtained results is carried out under the guidance of a teacher	the presentation and protection of the obtained results is carried out with the partial help of a teacher	independent competent and logical presentation and protection of the results obtained
constant striving to connect the future with the field of tribology profession with research activities	future professional activity is associated with the fulfillment of the circle of designated duties	the desire to partially link the future profession with research activities	A steady desire to link his profession with research activities

To determine the level of formation of students' research competencies, diagnostic tasks were developed, the formulation of which is divided into three levels. The tasks of the first level are the most difficult. They only indicate the problem. For second-level tasks, the problem remains the same, only the wording has been changed so that it contains hints.

The third level of tasks is simplified as much as possible, its formulation contains even more hints, but elements of creativity are still present in it. The following requirements were imposed on the tasks: accessibility to students of this stage of study, equivalence of options, availability of devices and materials when performing tasks, availability of necessary literature, ease of performing experiments, the ability to do work in one lesson (50 minutes). The division into three levels of formation of research competencies is based on the degree of independence of performing a diagnostic task.

High level - the student independently performs a creative task of the first level of complexity, does not use help cards to complete the task.

Intermediate level - the student performs a task of the second level of complexity, uses one or two help cards to complete the task.

Low level - the student performs a task of the third level of difficulty, when completing the task, he uses more than two help cards.

Here is an example of creative tasks using non-standard materials.

We have developed tasks that use a liquid magnetizing medium - a magnetic liquid. Senior students in classes in the discipline of specialization study various properties of this unique, widely used in various fields of engineering and tribophysics. Therefore, it is useful to introduce them to some of its properties in advance.

Here is a methodology for using creative tasks with the use of MF in the framework of a laboratory workshop. First of all, it is necessary to conduct an excursion to the scientific laboratory of "Physics of Magnetic Phenomena". To talk about the properties of magnetic fluid, the fields of application of magnetic fluid, to accompany interesting presentations of problems of electrodynamics - one of the considered problems of tribophysics.

To acquaint with the scientific literature available at the department and in the library of the university concerning the problems related to MJ. It is useful to visit, together with junior students, the research center "Surface Engineering and Tribology" created at the S. Amanzholov East Kazakhstan University. Here are examples of creative tasks using magnetic fluid.

For example, after completing the laboratory work "Domain structure of a ferromagnet", it is proposed to perform the following task:

Task 1. The first level of complexity: to investigate the influence of the magnitude of the intensity of the external magnetic field directed perpendicular to the layer of a two-phase magnetic fluid on the dimensional parameters of the labyrinth and hexagonal structures arising in the magnetic field.

To complete this task, the student must: 1. having studied the scientific literature, to identify the conditions for the formation of labyrinthine and hexagonal structures; 2. to develop an experiment plan; 3. to select the necessary devices; 4. from the proposed variants of the magnetic fluid to choose a suitable sample - a two-phase magnetic fluid; 5. to think about how to create and measure a homogeneous magnetic field directed perpendicular to the sample layer; 6. to think over ways to reduce errors; 7. to measure and process the results; 8. to conclude, present and protect the results obtained.

The second level of complexity: to investigate the effect of the intensity of the external magnetic field directed perpendicular to the layer of a two-phase magnetic fluid on the dimensional parameters of the labyrinth and hexagonal structures arising in the magnetic field using a microscope with an ocular micrometer and Helmholtz coils.

With this formulation of the task, the student will not have to independently select the necessary equipment, which can help him in completing the task. However, he must independently: 1. determine the price of dividing an ocular micrometer by one of the known methods (for example, using a diffraction grating); 2. using a microscope, find a two-phase magnetic fluid; 3. calibrate Helmholtz coils, for example, using a teslameter; 4. obtain structures whose dimensional parameters are small, and find a way to measure their linear dimensions, the error of which is minimal. For example, by measuring the total linear size of several periodic structures, divide by their number. Figure 2 shows photos of labyrinth structures obtained by students while performing this task.

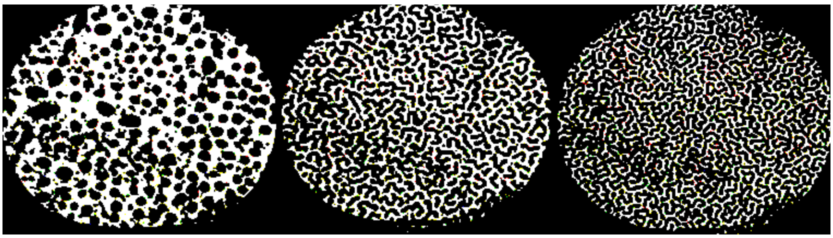

Figure 2. The labyrinth structure obtained by students when performing the task

The third level of complexity; to observe qualitatively the influence of the magnitude of the intensity of the external magnetic field directed perpendicular to the layer of a two-phase magnetic fluid on the dimensional parameters of the labyrinth and hexagonal structures arising in the magnetic field.

When solving a task of the third level of complexity, the student needs to fix the qualitative influence of the magnitude of the magnetic field on the size of the emerging labyrinth and hexagonal structures. To do this, you need: 1. Observe a two-phase magnetic liquid with a microscope; 2. Create a magnetic field using Helmholtz coils, the induction of which is directed perpendicular to the sample layer; 3. By changing the magnitude of the external magnetic field, observe the change in the dimensional parameters of labyrinth and hexagonal structures. 4.

Draw conclusions, present the results and explain the observed phenomenon. Such tasks are very interesting, students are happy to do them. They contribute to the development of research competencies regardless of abilities.

Help cards. It is not always possible to formulate a creative task in three levels of complexity. In such cases, students may be offered help cards in turn, which help to find the right solution. Tasks with help cards differ from multi-level tasks in that they are simpler. The help card is not a solution algorithm, but rather an indirect hint (of a creative nature). It is necessary that the help card be offered to the student on time, not too early or too late, otherwise interest in solving the creative task may be lost. Therefore, it is necessary for the teacher, having completed each task in advance, to carefully consider the actions of the student and make suggestive hints that do not give a direct answer, so that the task is simplified, but remains creative. If a student has proposed a solution that differs from the teacher's solution, it must be carefully considered, if it is incorrect, impossible in laboratory conditions or technically cumbersome, invite the student to think about a more rational solution. If the student's idea deserves attention, discuss the details of the solution and give the student the opportunity to bring the solution to the end.

The work of students was checked by both teachers leading the disciplines of specialization and leading classes in laboratory practice. The purpose of the double check is to reduce the possible subjectivity in assessing the level of formation of research competencies. The control and experimental groups contained the same number of students.

The results of the input control section conducted among the second-year students in the experimental and control groups are presented in Table 2.

Table 2 – Results of the control section of the second year students (entrance section)

Task number	The level of formation of research competencies, %					
	Level I (high)		Level II (medium)		Level III (low)	
	Control group	Experimental group	Control Group	Experimental group	Control Group	Experimental group
1	10,3	8,6	39,5	40,6	50,2	50,8
2	9,5	9,7	44,5	47,2	46,0	43,1
3	11,3	10,7	53,2	57,3	35,5	32,0
4	9,2	9,5	49,5	39,4	41,3	51,1

To evaluate the results of the formation of research competencies of physics students, the X^2 criterion was used, which allows comparing not the absolute average values of some quantities before and after the experiment, but the percentage distributions of data.

The formula of the X^2—criterion looks like this:

$$X^2 = \frac{1}{n_j n_k} \sum_{i=1}^{m} \frac{(n_j O_{kl} - n_k O_{ji})^2}{O_{kl} + O_{jl}}, \text{где}$$

n_j — is the number of students in the experimental group,

n_k — is the number of students in the control group,

O_{kl} — the number of control group students who fell into category I,

O_{ji} — is the number of students of the experimental group who fell into category i,

m— is the total number of groups into which the results of the experiment were divided. In our case, n is equal to 3, because we compared high, medium and low levels of formation of research skills.

The criterion allows us to test the null hypothesis about the reliability of the coincidence of the initial level of formation of research competencies in the experimental and control groups. Table 3 shows the data obtained when calculating the X^2 criterion.

Table 3 – X^2— CRITERION (input section)

Task number	X^2 – criteria
1	0,98
2	0,012
3	0,55
4	2,24

The critical value of the criterion for the significance level p = 0.05 and the number of degrees of freedom v = 2. Thus is inconsistent, the difference in the results in the experimental and control groups at the initial stage of the experiment is not statistically significant. Prior to the experiment, no statistically significant differences were found between the control and experimental groups of students.

The analysis of the results of the control cross-section conducted among the second-year students allowed us to draw the following conclusions:

• 42.5% (control group), 43.1% (experimental group) of subjects showed a low level of research competencies formed during their studies at school and in the first year of university; average level — 47.3% (control group) 46.8% (experimental group) of subjects; high level - 10.2% (control group),10,1% (experimental group) of subjects;

Thus, the ascertaining experiment revealed:

• insufficiently high level of formation of research competencies among junior, senior and graduate students;

• the traditional method of conducting a physical workshop is insufficient for the formation of a high level of research competencies.

The next stage of our research was a formative pedagogical experiment. During the formative experiment, the following task was solved: to test the effectiveness of the developed methodology for the formation of research competencies of undergraduate physics students in the framework of a laboratory workshop (using mini-studies). The levels of formation of research competencies of undergraduate physics students were determined by the results of a series of control sections, questionnaires. The results of the control section carried out after the experiment for 2nd-year physics students are presented in Table 4.

Table 4 – Results of the control section of the second-year students (after the experiment).

Task number	The level of formation of research competencies, %					
	Level I (high)		Level II (medium)		Level III (low)	
	Control group	Experimental group	Control group	Experimental group	Control group	Experimental Group
1	15,7	18,1	41,5	48,6	42,8	33,3
2	13,5	16,0	49,7	57,2	36,8	26,8
3	18,4	21,8	57,6	66,3	24	11,9
4	12,9	15,2	51,5	59,5	35,6	25,3

The data obtained during the calculation of the X^2 criterion are presented in Table 5.

Table 5 – X^2— CRITERION (2nd course)

Task number	X^2— criteria
1	6,25
2	6,33
3	6,10
4	6,13

As a result of statistical processing of the slice carried out at the control stage of the pedagogical experiment, the value of the X^2 - criterion equal to 6.18 was obtained. Since the results obtained during the experiment indicate significant differences between the samples, i.e. the proposed methodology contributes to improving the level of formed research competencies of students.

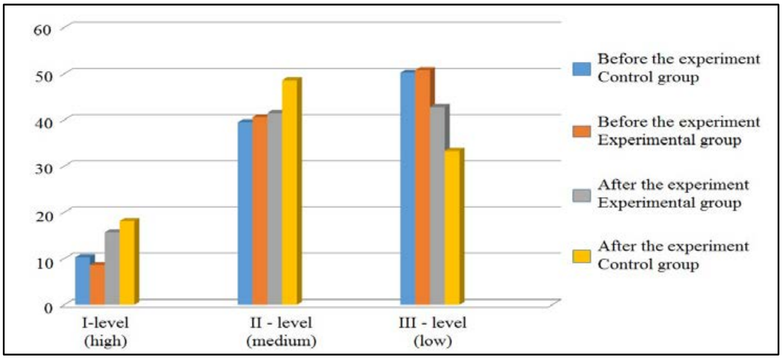

Figure 3. Dynamics of the formation of research competencies (according to the 1st task)

The results obtained allow us to conclude that the experimental group, even with further training, shows a higher level of formation of the Bachelor of Physics research competencies than the control group. Repeating the comparative diagnosis several times, as a result of which similar results were obtained, enhances the reliability of the results obtained.

Discussion. Galustyan, Borozdin, Pleshakov, Askhadulina, Radchenko, (2020) under research competence means the abilities and research skills related to the analysis and evaluation of scientific material. Thus, "research competence" in this study is understood as a combination of special human qualities with research skills that allows an individual to perform any type of research activity at a high level.

In our study, we adhere to the opinion of Amirova, (2020) who believes that when designing students' research activities, the model and methodology of research developed and adopted in the field of science over the past few centuries is taken as the basis. This model is characterized by the presence of several standard stages present in any scientific research, regardless of the subject area in which it develops. At the same time, the main purpose of educational research, from a functional point of view, is fundamentally different from that in the field of science. In the field of science, the main goal is the production of new knowledge in a general cultural meaning, and in education, the goal of research activity is to acquire students a functional research skill as a universal way of mastering reality through increasing motivation for learning activities and activating the student's personal position in the educational process, the basis of which is the acquisition of subjectively new knowledge (i.e. independently acquired knowledge, which are new and personally significant for a particular student) (Leonard & Wibawa, 2020).

The main method of teaching the experience of creative activity, as a result of which, in our opinion, the formation of research competencies is most effective, is the research method. However, I.Ya. Lerner emphasizes that in accordance with the law of piecemeal assimilation of any new and complex content of the experience of creative activity can be assimilated only piecemeal and operationally.

Nacu, Martin, & Pinkard, (2018) proposed a transition from a research method to a heuristic one, which, in our opinion, is most suitable for the formation of research competencies of undergraduate physics students and is taken by us as a basis. It consists in the following: "Students' difficulties in solving a problem problem are overcome by dividing it into a series of subtasks, replacing a complex task with a similar, but simpler one, in order to then return to the first one."

The analysis of literature and educational practice led to the conclusion that the purposeful formation of students' research competencies is not given due attention.

In previous works, a reliable understanding of the complexity and patterns of the general learning experience of physics students was developed through a combination of a contextual model of competence formation, categories of random competencies and student accounts that form narrative trajectories through learning (Schneider, 2019; Savrasova-V'un, 2021). Our study examines these results from the point of view of their significance for education in the field of tribology.

Conclusion. Research competencies of undergraduate physics students as a special personality trait, representing a balanced combination of stable motivation to conduct physical research and the ability to perform research work using physical methods, it is advisable and possible to form, using mini-studies as part of a laboratory workshop in general physics.The organization of such mini-studies increases the level of formation of research competencies of physics students of junior courses and prepares them for independent research work at the senior courses of the university. As a result, this increases the level of formation of research competencies of university graduates (Magaji, 2021).

The structural composition of the bachelor's research competencies- physics and indicators of their formation are revealed: positive motivation for research activities; sustained interest in working with sources of scientific information; activity in finding and solving research problems; conscious and rational implementation of the stages of research activities; competent analysis of research results; reasonable determination of the place and meaning of the result; competent and logical presentation and protection of the results obtained; a steady desire to link the future profession with research activities. The revealed structural composition and indicators of research competencies made it possible to develop diagnostics of the process of their formation in physics students.

The results obtained allow us to conclude that the organization of mini-studies in combination with reproductive methods within the framework of a laboratory workshop in physics contributes to the effective formation of research competencies of undergraduate physics students and, as a result, the formation of bachelor-physicists, which fully corresponds to the modern ideology of higher professional education. The methodology has been introduced into the educational East Kazakhstan University named after S. Amanzholov, as well as (partially) into the educational process of the International Kazakh-Turkish University named after H.A. Yassavi.

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МАЗМҰНЫ

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