

ABSTRACT

of dissertation work of Aigerim Abdulayeva on the topic «Preparing Pre-Service Physics Teachers to Foster School Students' Experimental and Research Skills in an Information-Educational Environment», submitted for the degree of Doctor of Philosophy (PhD) on the educational programme 8D01502-Physics

Relevance of the study. Modern trends in the development of education require from the teacher not only deep subject knowledge, but also the ability to design and construct an effective educational environment in the conditions of information flow. Education of the 21st century is aimed at developing skills of effective work with information, critical thinking, digital and functional literacy. These skills are necessary to prepare students for life in the conditions of global scientific and technological progress. Using the possibilities of information educational environment in teaching allows physics teachers to realise these tasks with the help of modern tools. As Andreas Schleicher, who founded the PISA study, put it: «The quality of education will never be higher than the quality of teachers». This conclusion defines the key role of the teacher in creating an effective educational environment to develop students' scientific literacy and critical thinking.

President of the Republic of Kazakhstan Kassym-Jomart Tokayev in his Addresses to the Nation has repeatedly emphasized the importance of the quality of education and training of highly qualified teachers. The message of 1 September 2022 states: «a significant factor in the formation of a successful nation is the quality of secondary education. Every Kazakhstani schoolchild must have decent conditions for learning and all-round development. ... I am deeply convinced that school teachers will play a decisive role in building a Just Kazakhstan». The President singled out a new standard for accreditation of teacher training colleges and the need to define the scope of teachers' competence. These tasks are also aimed at improving the quality of training of future teachers.

The importance of forming research skills of students and digital literacy of teachers at the level of state policy in the country is reflected in regulatory documents. In accordance with the «Concept of development of preschool, secondary, technical and vocational education in the Republic of Kazakhstan for 2023 - 2029 years», approved by the Government of the Republic of Kazakhstan on 28 March 2023 № 249, the main directions of education reform are: improvement of curricula, introduction of digital technologies and improving the functional literacy of students.

In addition, in the «Concept of development of higher education and science in the Republic of Kazakhstan for 2023 - 2029» (Resolution of the Government of the Republic of Kazakhstan dated 28 March 2023 No. 248) states that in order to improve the quality of education at school, it is necessary to improve the training of future teachers (especially in digital technologies and research activities).

The professional standard «Teacher», approved by the Order of the Acting Minister of Education and Science of the Republic of Kazakhstan dated 15

December 2022, No. 500, establishes certain requirements for teacher competence, including the ability to organize students' research activities and use modern educational technologies.

The results of the international PISA study emphasize the need to improve teachers' « readiness to develop students » research activities. Kazakhstan has been participating in the study since 2009, and PISA-2025 focuses on science literacy and the innovative direction of « learning in the digital world ». It assesses students' self-learning abilities using digital tools such as virtual labs, online courses and browsers. This requires the teacher not only to have knowledge of modern technologies, but also to be able to integrate them into the learning process.

The modern information educational environment not only expands the possibilities of learning, but also poses new challenges to the physics teacher in organizing a physics teaching experiment. Physics as an experimental science requires not only mastering of theoretical material, but also active participation of students in research work, which is especially important in the conditions of digital transformation of education.

In this regard, the training of a future physics teacher should include not only mastering the means of information educational environment, but also preparing students to form experimental-research skills. The teacher should be able to design the means of the information educational environment not only to increase visibility, but also in such a way that students independently conduct research, analyze the results and draw scientific conclusions with the help of the means of the information educational environment.

Thus, the training of future physics teachers to form experimental-research skills of students in the conditions of information educational environment is relevant at present. The solution of this problem will provide quality physics teaching in accordance with the requirements of the modern education system.

In accordance with the topic of the research the works of domestic and foreign scientists have been analyzed:

- issues related to the improvement of teaching methods, improving the quality of teaching physics and mathematics disciplines were investigated by such scientists as A.E.Abilkasymova, D.M.Kazakbayeva, S.N.Nurkassymova, S.M.Seitova, G.B.Alimbekova, M.S.Moldabekova, E.A.Tuyakov, A.A.Akzholova, B.Yerzhenbek, etc.;

- formation of students' learning skills studied by A.V.Usova, A.A.Bobrov, A.V.Peryshkin, V.G.Razumovsky, N.S.Purysheva, Zh.M.Bitibaeva, E.S.Kodikova, E.S.Dementieva, etc.;

- organisation of educational experiment at physics lessons are studied in the works of E.S.Sarmanov, T.S.Nurbatyrova, K.S.Shadinova, N.A.Sandibaeva, K.T.Namazbayev, B.A.Kurbanbekov, R.Trumper, etc.;

- application of means of information educational environment studied by I.V.Robert, B.S.Akhmetov, E.I.Bidaybekov, B.E.Starichenko, N.N.Kerimbayev, G.B.Issayeva, N.Zh.Zhanatbekova, Sh.J.Ramankulov, J.Kuhn, P.Vogt, etc.

In research work, the information educational environment is considered as a set of software and hardware, educational and methodological, information and

communication and intellectual systems (including artificial intelligence technologies), providing the educational process and aimed at achieving the educational results of students.

Despite a significant number of scientific works carried out in the direction of research, the preparation of future physics teachers to the formation of experimental-research skills of students in the information educational environment is still a subject of study. Based on the analysis of the state of theoretical research and practical implementation of this problem, the following **contradictions** were revealed:

-between the wide possibility of using the means of information educational environment in the formation of students' experimental-research skills and the narrow scope of application of these means in teaching;

-between the need to train future physics teachers to organize students' experimental-research activity in the conditions of information educational environment and the insufficient development of theoretical and methodological foundations that ensure its implementation.

These contradictions allowed us to identify the relevance of the research topic and formulate the *research problem*: what should be the methodological system of training future physics teachers to comprehensively use the possibilities of information educational environment in the formation of experimental-research skills of students?

On this basis the theme of the dissertation work was chosen as «Preparing Pre-Service Physics Teachers to Foster School Students' Experimental and Research Skills in an Information-Educational Environment».

The aim of the research: theoretical and methodological substantiation of the methodology of Preparing Pre-Service Physics Teachers to Foster School Students' Experimental and Research Skills in an Information-Educational Environment.

Object of the research. The process of training future teachers of physics.

Subject of the research. Methodology of training future physics teachers to form experimental-research skills of students when teaching physics in the information educational environment.

Hypothesis of the research: *if* the training of future physics teachers to form experimental-research skills of students takes into account the possibilities of information educational environment, the specifics of the content of physics as a subject, the stages of research activity, their implementation is methodically justified and implemented in the educational process, *it is possible* to bring future specialists to a high level of training to form experimental-research skills of students, *because* the experimental-research skills formed in students satisfy the needs of society and create opportunities for professional development of future physics teachers in the conditions of information educational environment.

Objectives of the study.

- to determine the theoretical and methodological foundations for the formation of students' experimental-research skills when teaching physics in the information educational environment;

- to determine the pedagogical potential of the information educational environment of the school in the organisation of experimental-research activity of students;

- to develop a model of Preparing Pre-Service Physics Teachers to Foster School Students' Experimental and Research Skills in an Information-Educational Environment;

- to develop a methodology of training future physics teachers to form experimental-research skills of students using the means of information educational environment and to test its effectiveness in the course of the pedagogical experiment.

The following research methods were used to solve the set tasks:

- *general scientific methods of theoretical research*: analysis of normative documents, psychological, pedagogical and scientific and methodological research on the problem of training future physics teachers to form experimental-research skills of schoolchildren using the possibilities of information educational environment, collection of theoretical material and study of methodological literature, classification and generalization of the obtained results.

- *methods of sociological research*: modeling of the process of professional training of future physics teachers in order to form experimental-research skills in teaching physics in the information educational environment; observation, questionnaires, interviews among schoolchildren, physics teachers, students;

- *empirical research methods*: conducting a pedagogical experiment to confirm the research hypothesis, analyzing and processing the results of the experiment using statistical methods.

Theoretical and methodological foundations of the research:

- psychological and pedagogical research on the problem of formation of learning skills (A.V.Usova, Y.B.Babansky, P.Y.Galperin, A.N.Leontiev, E.I.Kabanova-Meller, N.F.Talyzina, I.Y.Lerner, N.S.Puryшева);

- researches on application of means of information educational environment in teaching (I.V.Robert, B.S.Akhmetov, E.I.Bidaybekov, B.E.Starichenko, N.N.Kerimbayev, G.B.Issayeva, N.Zh.Zhanatbekova, Sh.Zh.Ramankulov, J.Kuhn, P.Vogt),

- basics of system-activity approach in teaching (S.L.Rubinstein, V.V.Davydov, A.N.Leontiev, P.Y.Galperin, L.S.Vygotsky, D.B.Elkonin);

- issues of organisation of experimental-research activity of students in the theory and methodology of teaching physics (A.V.Usova, A.A.Bobrov, N.S.Purshева, M.S.Moldabekova, K.T.Namazbayev, Zh.M.Bitibayeva, E.S.Kodikova, N.V.Kochergina);

- theories of integration of information and communication technologies in education (I.Ajzen, M.Fishbein, F.D.Davis, L.G.Tornatzky, M.Fleischer, A.K.Chakrabarti).

Sources of the study: the idea of the study is based on the main normative and strategic documents aimed at the development of the country's education system, the Law of the Republic of Kazakhstan «On Education», the concepts of development of preschool, secondary, technical and vocational education, science

and higher education (2023-2029), state obligatory standards of education, professional standard «Teacher», as well as the concept of development of artificial intelligence (2024-2029).

Scientific novelty of the research:

- theoretical and methodological bases of formation of students' experimental-research skills when teaching physics in the information educational environment were determined;
- the pedagogical potential of the information educational environment of school in the organisation of experimental-research activity of students was revealed;
- the model of training future physics teachers to form experimental-research skills of students in the information educational environment has been created;
- the methodology of training future physics teachers to form experimental-research skills of students using the means of information educational environment has been developed.

Theoretical significance of the research: psychological and pedagogical aspects of formation of experimental-research skills of students, criteria and indicators of the level of formation of experimental-research skills of students, classification of means of information educational environment, possibilities of using means of information educational environment in the formation of experimental-research skills of students, components of training of future teachers of physics to the formation of experimental-research skills.

Practical significance of the study: the model «Preparing Pre-Service Physics Teachers to Foster School Students' Experimental and Research Skills in an Information-Educational Environment» proposed in the study, the algorithm of forming experimental-research skills of students in the information educational environment can serve as a methodological help in teaching students of the group of educational programmes «training of physics teachers B010». The electronic textbook «School Physics Experiment», MOOC «Laboratory Work in Physics», textbook «Physics Teaching Experiment and Processing of its Results» prepared in the course of the research are used in the teaching process. The results obtained in the course of the research work and the specific scientific and methodological recommendations prepared on their basis, research materials can be used in the practice of pedagogical universities, physics teachers, in the system of improving the qualification of physics teachers.

The main provisions recommended for defence:

- information educational environment - a set of software and hardware, educational and methodological, information and communication and intellectual systems (including artificial intelligence technologies), providing the educational process and aimed at achieving the educational results of students;
- in training future physics teachers to develop students' experimental-research skills in the information educational environment, it is necessary to proceed from the principle of continuity. The principle of continuity provides a logical connection between subjects, allowing students to systematically master the

means of the information educational environment and apply them in various learning situations;

- preparation of future physics teachers to form experimental-research skills of students in the information educational environment consists of interrelated target, project-planning, activity, motivational and result components;

- training of future physics teachers should include theoretical training, which deals with the practical application of methodological foundations, theoretical problems and tools of the information educational environment, after which this knowledge is necessarily applied in the course of pedagogical practice, where future teachers conduct classes on this methodology, practise and adapt it in specific teaching situations.

The results of the research are reflected in publications and reports at conferences of different levels: IEEE International conference on Smart Information Systems and Technologies (SIST), International Conference on Mathematics, Science and Technology Education (ICon-MaSTEd), the Barcelona Conference on Education; Republican scientific and methodological seminar «Problems of continuity of teaching mathematics and physics at school and pedagogical university in the conditions of digital educational environment» on the basis of KazNPU named after Abai; competition of projects of commercialisation of the results of scientific and scientific-technical activity of young scientists; scientific seminars and meetings of the Faculty of Physics and Mathematics of I.Zhansugurov Zhetysu University.

Research base. The main experimental work was carried out on the basis of NPJSC «Zhetysu University named after I. Zhansugurov» and secondary schools of Zhetysu region.

The main stages of the research. A confirmatory, exploratory and formative experiment was conducted between 2019 and 2024

The first stage (2019-2020). The purpose of the establishing experiment: to identify and study the state of the problem of training a future physics teacher to organise students' teaching and research activities in the educational process. At this stage, the normative documents in the field of education were analysed, scientific-methodical and psychological-pedagogical literature devoted to the problems of formation of students' experimental-research skills in the information educational environment was analysed.

The second stage (2020-2022). At the stage of exploratory experiment the model of training future physics teachers to form experimental-research skills of students in the information educational environment was developed. In the course of the work, methodological materials for students of pedagogical universities were prepared, ways of organising a physics teaching experiment were proposed. The criteria for assessing the level of formation of students' experimental-research skills were also determined. Special attention was paid to the introduction of the means of information educational environment into the educational process, which allowed to strengthen the experimental-research component in teaching physics.

The third stage (2022-2024). The stage of the forming experiment included the approbation of the proposed model and the developed methodological material.

During the experiment the level of formation of students' experimental-research skills was analyzed, the motivation of future physics teachers to use the means of information educational environment in their professional activity was investigated, statistical and substantive processing of the results of the pedagogical experiment was carried out.

Publications. The main content of the thesis was published in Scopus database journals; journals recommended by the Committee for Quality Assurance in the field of science and higher education, discussed at foreign and domestic international scientific-practical conferences, at scientific seminars of the department. On the main content of the thesis published 27 research papers.

In the publications included in the Scopus database:

1. Fostering AI literacy in pre-service physics teachers: inputs from training and co-variables //Frontiers in Education. – Frontiers Media SA, 2025. – Т. 10. – P. 1505420. (co-authors: Zhanatbekova N., Andasbayev Y., Boribekova F.) The contribution of the doctoral student 70 %.

2. Abdulayeva A. B. Rapid foresight: Information technologies in Physics lessons //Journal of Physics: Conference Series. – IOP Publishing, 2024. – Т. 2871. – №. 1. – P. 012012. The contribution of the doctoral student 100 %.

3. Using smartphones in home education to perform physics lab //2021 IEEE International Conference on Smart Information Systems and Technologies (SIST). – IEEE, 2021. – P. 1-4. The contribution of the doctoral student 100 %.

In the publications recommended by the Committee on Quality Assurance in the field of science and higher education of the Ministry of Higher Education of the Republic of Kazakhstan:

1. ХХІ ғасыр дағдыларын дамыту үшін ақпараттық-коммуникациялық технологияларды қолдану // The bulletin of KazATC. – 2024. – Т. 133. – №. 4. – P. 323-333. (co-authors: Жанатбекова Н.Ж.) The contribution of the doctoral student 70 %.

2. Физиканы оқытуда компьютерді қолдану мүмкіндіктері: оптика бойынша зертханалық жұмысты орындау мысалында // Bulletin of Abai KazNPU. Series of Physical and Mathematical Sciences. – 2024. – Т. 88. – №. 4. – P. 198-208. (co-authors: Сакибаева Б.Р., Жакпаев К.Р., Жанатбекова Н.Ж.) The contribution of the doctoral student 75 %.

3. Жаппай ашық онлайн курстарды білім беруде қолдану мәселелері // Bulletin of Abai KazNPU. Series of Pedagogical Sciences. – 2023. – Т. 4. – №. 79. – P. 116-125. (co-authors: Ахметов Ж. У., Жанатбекова Н. Ж.) The contribution of the doctoral student 80 %.

4. Ақпараттық-коммуникациялық технологияларды білім беруде қолдану мәселелері // Bulletin of Abai KazNPU. Series of Pedagogical Sciences. – 2022. – Т. 73. – №. 1. – P. 196-204. (co-authors: Жанатбекова Н. Ж., Майлыбаева Г. С.) The contribution of the doctoral student 60 %.

5. Физика сабақтарындағы оқушылардың зерттеушілік іс-әрекеті // Bulletin of Abai KazNPU. Series of Pedagogical Sciences. – 2021. – Т. 72. – №. 4. – P. 222-233. (co-authors: Жанатбекова Н. Ж., Есенгабылов И. Ж.) The contribution of the doctoral student 80 %.

6. Formation of research competence of students at the process of studying the viscosity of a liquid // Bulletin of Abai KazNPU. Series of Physical and Mathematical Sciences. – 2020. – Т. 72. – №. 4. – P. 85-91. (co-authors: Акжолова А.А., Косов В.Н.) The contribution of the doctoral student 30 %.

7. The role of thought experiments in the development of students' scientific thinking // Science and life of Kazakhstan. - 2020. - №12/1 (147). - P. 92-95. (co-authors: Жанатбекова Н. Ж.) The contribution of the doctoral student 80 %.

8. Formation of scientific worldview of students in laboratory work // Science and life of Kazakhstan. - 2019. - №10. - P. 72-77. (co-authors: Жанатбекова Н.Ж., Турсынбаева Д.А., Борибекова Ф.) The contribution of the doctoral student 60 %.

9. Білім беру процессінде ақпараттық-коммуникациялық технологияларды қолданудың маңызы // Science and life of Kazakhstan. - 2019. - №10. - P. 33-39. (co-authors: Андасбаев Е.С., Түсүмбаева М.) The contribution of the doctoral student 60 %.

In the materials of the international scientific conference abroad:

1. Bridging 21st Century Skills and ICT Integration in Physics Education: A Bibliographic Analysis – The Barcelona Conference on Education 2024: Official Conference Proceedings (pp. 675-682) (co-authors: Жанатбекова Н. Ж.) The contribution of the doctoral student 80 %.

In other scientific journals:

1. The Role of Lesson Planning and Design in the Learning Process // Bulletin of Dulaty University. – 2024. – №. 2. – P. 67-74. The contribution of the doctoral student 100%.

2. Optics Practice Problems Solutions using Python// Тенденции развития науки и образования. – 2023. – No. 95-2. – P. 51-53. The contribution of the doctoral student 100 %.

3. Study of mechanical motion by stroboscopic method // Bulletin of Zhetysu University named after I. Zhansugurov. – 2023. – №. 4 (109). – P. 16-20. (co-authors: Мұхтарғали М. М.) The contribution of the doctoral student 80 %.

4. Formation of research skills of students when performing laboratory work in physics: Virtual laboratory vs smartphone-based laboratory // Cypriot Journal of Educational Sciences. – 2022. - №12. - P. 4303-4310. (co-authors: Zhanatbekova N., Andasbayev Y., Zhiyembayeva Zh., Urazova M.) The contribution of the doctoral student 40 %.

5. Домашний физический эксперимент в условиях информационной образовательной среды // Актуальные вопросы образования и науки. – 2022. – № 2(74). – P. 33-36. (co-authors: Жанатбекова Н. Ж.) The contribution of the doctoral student 70 %.

6. Organization of students' research activities in the study of the topic «Interference of light» // Bulletin of Zhetysu University named after I. Zhansugurov. – 2022. – №. 4 (105). – P. 8-12. The contribution of the doctoral student 100 %.

7. Развитие познавательной деятельности обучающихся на основе учений аль-Фараби // Актуальные вопросы образования и науки. – 2020. – № 2(70). – Р. 23-25. (co-authors: Андасбаев Е. С., Жанатбекова Н. Ж.) The contribution of the doctoral student 70 %.

Textbook:

1. Физикалық оқу эксперименті және оның нәтижелерін өңдеу: оқу құралы – Taldykorgan: Publishing Department of I. Zhansugurov Zhetysu University, 2022. –104 p. (co-authors: Жанатбекова Н. Ж.) The contribution of the doctoral student 60 %.

Certificate on entering information into the state register of rights to copyrighted objects - 5.

Patent for utility model - 1.

Reliability and validity of the study. The main conclusions and results of the study were heard and discussed at scientific and methodological seminars of the Department of Physics-Mathematics of ZhU named after I. Zhansugurov, and also found their reflection in the electronic textbook «Physical experiment of school», mass open online course «Laboratory work in physics», textbook «Physical teaching experiment and processing of its results». In addition, the results of the study were reported during the scientific internship at the Department of Physics of the Kazakh National Pedagogical University named after Abai (Kazakhstan, Almaty).

The *structure of the thesis* is determined by the purpose and logic of the research. The thesis consists of normative references, notations and abbreviations, an introduction, three sections, a conclusion, a list of references used and supplementary material.

The introduction substantiates the relevance of the chosen research topic, defines the object, subject, goal, objectives and research methods, describes the scientific novelty, theoretical and practical significance of the work, substantiates the conclusions presented for defence.

The section «Theoretical bases of formation of experimental-research skills of students when teaching physics in the information educational environment» is devoted to the analysis and substantiation of theoretical bases of formation of experimental-research skills of students in the conditions of information educational environment. The analysis of psychological and pedagogical studies is carried out, the possibilities of information educational environment for the organisation of experimental research activity of students are determined.

The section «Methodological bases of Preparing Pre-Service Physics Teachers to Foster School Students' Experimental and Research Skills in an Information-Educational Environment» describes the peculiarities of training future physics teachers to use the possibilities of the information educational environment in the organization of students' experimental-research activity. The model of preparation of future physics teachers consisting of target, project-planning, activity, motivational and result components to the formation of experimental-research skills of students in the information educational environment is also presented.

The section «Pedagogical experiment and its results» presents the characteristics of the pedagogical experiment conducted in the course of the thesis research. The stages of the experimental research, the course of its organization, the methods used and the results obtained are described.

The conclusion contains the main conclusions characterizing the results of the thesis research.

Literature consisting of 204 titles was used in conducting the thesis research.

The appendices contain the materials used in the study, survey questions, author's certificates and acts on the inclusion of research work in the educational process.