

## ANNOTATION

**dissertation work of Auyelbek Murat on the topic "Training of future teachers of physics, computer science for teaching robotics at school (based on a modular approach)", submitted for the degree of Doctor of Philosophy (PhD) in the educational program 8D01101 - "Pedagogy and Psychology"**

At present, significant changes in the national education policy are taking place in our country. These changes are reflected in the Addresses of the President of the Republic of Kazakhstan Kassym-Jomart Tokayev and are aimed at improving the well-being of the country. The National Action Plan for the implementation of the Address of the Head of State to the people of Kazakhstan dated September 1, 2021 "Unity of the People and Systemic Reforms" basically contains strategies aimed at positive changes in the country.

The Strategic Development Plan of the Republic of Kazakhstan until 2025, the Law of the Republic of Kazakhstan "On the Status of the Teacher" dated December 27, 2019 No 293-VI enshrines the initiative to provide legislative conditions for the development of the latest technologies, provided for as part of the task of developing infrastructure and removing barriers to digitalization and the need to improve the effectiveness of professional training of future teachers.

In addition, it should be noted that the President of the Republic of Kazakhstan instructed to increase the countrywide innovative, scientific and technical development (paragraph 8) of paragraph 3 of the minutes of the meeting №19-01-7.30 dated August 23, 2019. As a result, the adoption of such legislative norms leads to a further increase in the innovative activity of the population, an improvement in the country rating. In terms of education, this is the application of the latest technological and methodological research and the earliest possible replacement of irrelevant standards. Since 2018, Kazakhstan has been implementing the state program "Digital Kazakhstan", which identifies five priority areas, among which the most important are "Digitalization of Economic Sectors" and "Development of Human Capital". These initiatives, or rather transformations in these areas, also contribute to building a creative society to ensure the transition to new realities – the knowledge economy. In this context, the problem of robotic education is actualized.

Reforming the higher education system in Kazakhstan is characterized by the search for an optimal match between the existing experience in higher education and new challenges associated with entering the world educational space. The innovations of the university are also determined by the degree of enrichment of the university with modern information and communication technologies, wide inclusion in the Internet system. All universities are following the path of intensive accumulation of digital educational resources, new functioning in the system of

interactive education. In this context, the wide sphere of influence of robotics on the activities of society and the rapidly increasing scale of its implementation in the social environment actualize the further study of this field of knowledge. It is important to form the level of technical culture in the younger generation. At this stage of the country's economic development, the task is to continue improving IT competence and more active use of artificial intelligence.

Starting with higher educational institutions of the country and ending with preschool education, there are elective courses in various areas of educational robotics, however, the issue of targeted training remains unresolved. The Ministry of Education and Science made a one-time attempt to solve the issue through the retraining of teachers of computer science and physics, but universities are obliged to make their further contribution to solving the important task of training future teachers of computer science and physics to teach educational robotics. It should be noted that the needs for methodological assistance associated with the interdisciplinarity of educational robotics and its integration are relevant in many countries, as evidenced by such authoritative sources as WoS, Scopus, MDPI and others.

Thus, the relevance of the study is due to the lack of targeted training of robotics teachers, despite the fact that work is currently underway on the use of educational robotics in preschool institutions and schools, and specialists in this field are required. In pedagogical science, there is still no specific paradigm for teaching robotics in the context of preschool, school and higher education, a purposeful methodology for the use of educational robotics has not been developed, despite its wide interdisciplinary capabilities. In fact, this is an insufficiently developed process in the system of additional development. First of all, this is due to the fact that educational robotics is located in an informal educational context. Based on the needs of the Kazakh industry in the training of technical specialists, as well as the lack of qualified personnel in robotics, the proposed initiative to train future teachers of physics and computer science at the university to teach educational robotics is new and very relevant. It is assumed that they will be able not only to be competent in their field, but also in the field of educational robotics and to act as teachers of educational robotics. Educational materials designed for robotics classes are focused mainly on supporting additional education. Limiting robotics classes to extracurricular and elective activities does not contribute to the complete solution of the problems of technical education. At present, there is a high degree of discrepancy between the demand for scientific research in educational robotics, empirical data and available supply. For the further development of theory and practice in this context, it is necessary to study and solve problems associated with the dynamic permanent development of this area in a timely manner. The solution of the problems

of scientific, technical and socio-economic development of the country is inseparable from the solution of issues of development and improvement of the education system, reflecting the level of development of society. For teaching educational robotics, it is important and necessary for teachers to rethink robotics as a pedagogical educational direction for both teachers and students. Practicing teachers need scientific knowledge and developments, ready-made proven sources that can be used in the classroom. Researchers, in turn, need to be informed about these specific needs. Overcoming such and many other inconsistencies is an urgent problem in the era of the rapid scientific and technological revolution and globalization. Research centered around educational robotics is certainly related to the innovative world experience and processes taking place in the field of teaching and the application of specific methods and technologies, where robotics is on the one hand a tool, on the other hand, an interdisciplinary strategy.

We are talking not only about the expected economic benefits of robotics, but also about the role of the future qualified teacher as a source of technological knowledge. Thus, one of the topical issues is the training of teachers in universities, which in all senses is much more profitable than further retraining. Retraining should be carried out, as is traditionally accepted, to update knowledge and skills in connection with innovative changes, world trends in this area.

The works of scientists Banzi M., Blank D., Kumar D., et al, Alfieri L., Higashi R., et al., Alimisis D., Pina A. & Ciriza I., Ucgul M. M.G. Ershov, G.E. Senkina, Zh.K. Nurbekova, A.Zh. Asainova, K.M. Mukhamedieva contributed to the introduction of educational robotics in the training programs of future teachers.

In addition, the improvement and development of modern information and communication technologies has a great impact on the nature of scientific research, education, culture, life, social relations, etc. This directly affects the content of knowledge related to the level of scientific and technical achievements, and is also associated with the emergence of new specialties in the field of robotics. Among the most important areas of development and improvement of the education system, the issues of informatization of the educational process and fundamentalization of the content of education are also of great importance. At the same time, it should be noted that the informatization of the educational process is also a complex and, first of all, pedagogical problem. The use of modern information and communication technologies in the educational process should be pedagogically tested and expedient. The problems of informatization of the educational process lie not only in saturating the lesson with modern information and communication technologies, but also in creating appropriate pedagogically justified teaching methods aimed at the effective use of modern computer-oriented methodological systems for teaching various disciplines and means of a creative approach to ICT in solving various

problems. Digitalization in the education system is devoted to the works of E.I. Bidaybekov, T.O. Balykbaev, A.E. Sagimbayeva, Zh.K. Nurbekova. The theoretical basis of the research is made up of works related to the typology of educational robotics, interdisciplinarity and transdisciplinarity. P. C., Palfreyman, J., & Otten, W. Knapp, C. N., Reid, Von Wehrden, H. et al. Y.A. Vagramenko Mirsky E.M. G.M. Tulchinsky El-Hamamsy, L., et al., Maguth, B. M.

It is very important to understand that in order to solve all the problems in this context, educational robotics occupies a very important place.

The relevance of solving actual and hypothetical issues related to teaching educational robotics suggests further integration of scientific achievements and empirical data.

The teaching staff is systematically introducing new tools and updating methods, but the introduction of educational robotics into the general educational process will present certain difficulties for the practice of non-core teachers. They need methodological assistance and training in a convenient format. The relevance and problematic nature of studying the pedagogy of educational robotics remains, despite the fact that it has been in the mainstream of academic discourse for half a century, interest in it is still strong, as its interdisciplinarity and adaptability to increasing digitalization are increasing, and it is actively integrating with other disciplines (Jung, S., & Won, E.-S. A quarter of a century ago, the potential for cooperation in educational robotics was recognized and the systematic growth of modern education's attention to robotics was realized (Miller, D. P. & Nourbakhsh, I., continues to the current technological direction.

Thus, M.G. Ershov's dissertation research examines the issue of applying elements of educational robotics as a means of implementing the polytechnic focus in physics education. K.M. Mukhamediyeva's dissertation research explores the issue of identifying the theoretical and practical foundations for designing and implementing educational technologies in robotics at a pedagogical university based on the methodology of pedagogical design.

Thus, our analysis revealed a number of **contradictions**:

- between the need of the Kazakh industry for the human resources of modern robotics and the problems of training students in this area;
- between the possibility of integrating educational robotics into the content of subject courses and its preferential study in the system of an elective course;
- between the need for educational and methodological support in the context of interdisciplinarity and the lack of a clear basic paradigm.

The resolution of these modern contradictions allows us to formulate the problem: what should be the methodology for organizing the training of future teachers of physics and computer science to teach educational robotics.

In accordance with this problem, the research topic is formulated: "Training of future teachers of physics and computer science to teach educational robotics based on a modular approach".

**The purpose of the study is to scientifically** substantiate the specifics of the methodology of teaching educational robotics at the university and the implementation of the methodology for organizing training of future teachers of physics and computer science to teach robotics.

**The object of the research** is the process of training future teachers of physics and computer science to teach educational robotics in the system of higher pedagogical education.

**The subject of the research** is the theoretical and practical foundations of training future teachers of physics and computer science to teach educational robotics based on a modular approach.

**The hypothesis of the research** is that *if* future teachers of physics and computer science are trained according to the developed scientifically based methodology for organizing training in robotics disciplines in the context of a modular approach, it is possible to ensure a sufficient level of their training for teaching robotics, which will contribute to both improving the quality of professional training of future teachers of physics and computer science, and training as teachers of robotics, as well as contributing to improving the level of technical culture in the conditions of a wide sphere of influence of robotics on the life of society.

To achieve this goal and prove the hypothesis, we have formulated the following **research objectives**:

1. To study the state of the problem from the point of view of interdisciplinarity. To substantiate the need and possibility of training future teachers of physics and computer science to teach educational robotics at school.

2. Based on the psychological and pedagogical features of preparation for interdisciplinary integration, to develop a methodology for organizing the training of future teachers of physics and computer science to teach robotics.

3. Based on the project method, develop a prototype of a training platform and a mobile application for teaching educational robotics

4. To experimentally test the ways of training future teachers of physics and computer science to teach educational robotics.

**Research methods.** To solve the tasks and verify the theoretical provisions put forward in the dissertation, both theoretical and empirical methods were used: general theoretical and specific pedagogical plan; data collection and storage; experiment and implementation of the results. In order to identify the most common concepts of educational robotics research in the literature, a thematic analysis of the

key concepts of the topic of educational robotics was carried out. One of the main concrete pedagogical methods was the theoretical analysis of pedagogical sources.

### **Theoretical and methodological basis of the study.**

Since the methodological functions are performed by the entire system of philosophical knowledge, it follows that the first level is the philosophical level of **methodology**, which consists of the general principles of cognition. The general scientific methodology in the work is represented by system and technological approaches aimed at implementing the technology of modernizing the pedagogical practice of teaching educational robotics.

The theoretical basis of the research is made up of works related to the typology of educational robotics, interdisciplinarity and transdisciplinarity. Jean Piaget, Erich Jantsch, André Lichnerowicz, Bammer, G., Bernstein, J. H., Baveye, P. C., Palfreyman, J., & Otten, W., Knapp, Mittelstraß, J., Defila & Di Giulio, Mirsky, E.M., G.M. Tulchinsky, El-Hamamsy, L., et al., Maguth, B.M.

The works of scientists from far and near abroad, as well as domestic researchers: Banzi M., Blank D., Kumar D., et al., Alfieri L., Higashi R., et al., Alimisis D., Pina A. & Ciriza I., Ucgul, M.Y. Vagramenko, Zh.K. Nurbekova, A.Zh. Asainova and others, contributed to the introduction of educational robotics in the training programs of future teachers.

### **Sources of research.**

The Law of the Republic of Kazakhstan "On Education", the State General Education Standard of Higher Education, the Professional Standard "Teacher", the Address of the Head of State to the people of Kazakhstan, documents in the field of education, research works of domestic and foreign scientists in the field of pedagogy, psychology, educational robotics, official materials of the Ministry of Science and Higher Education of the Republic of Kazakhstan, regulatory documents of the Republic of Kazakhstan, etc.

### **Scientific novelty.**

1. Educational robotics as an object of interdisciplinary discourse and psychological and pedagogical features of preparation for interdisciplinary integration are investigated.

2. The main prerequisites for training future teachers of physics and computer science to teach robotics have been studied.

3. A methodology for organizing training for future teachers of physics and computer science for teaching robotics is proposed.

4. Based on the project method, a prototype of a training platform for teaching robotics has been developed.

**The theoretical significance of the study** lies in the fact that the main features and prerequisites for the training of future teachers of physics and computer

science to teach robotic disciplines that meet the basic requirements of higher pedagogical education are substantiated.

**The practical significance** lies in the fact that a mobile application and a training platform for teaching robotics have been created, which can be used in convenient formats. The dissertation research examines topical problems and solutions, as well as methods that can be useful in the light of modern requirements for undergraduates, doctoral students and young teachers.

**The reliability and validity of the obtained results** are ensured by the analysis of modern scientific and methodological literature; as well as the application of a set of research methods for collecting and processing data, which confirm the accuracy and validity of the experimental work and the study as a whole.

**The following provisions are submitted for defense:**

- Theoretical foundations of the study of educational robotics from the perspective of its interdisciplinarity;
- Psychological and pedagogical preparation for interdisciplinary integration as an instructional and methodological component in higher education institutions;
- The expediency of training future teachers of physics and computer science to teach educational robotics on the basis of teaching robotic disciplines instead of retraining;
- The methodology of rational training of students should be based on project activities.

**Research base:** the experimental study was conducted at the I. Zhansugurov Zhetysu University and the Caspian University of Technologies and Engineering named after Sh. Yesenov.

**Stages of the research.** In accordance with the goals and objectives, the research was conducted in three stages:

*At the first stage of the experimental work, a diagnostic experiment (2020-2021) was conducted, which aimed to identify the insufficient development of the methodology for teaching educational robotics in the context of enhancing the readiness of future physics and computer science teachers for pedagogical activities. At this stage, based on the analysis of pedagogical and methodological literature, as well as literature on information technologies in education related to the research topic, the level of development of the research problem in pedagogical theory and practice was determined. The object, subject, purpose, and objectives of the research were identified, and the research hypothesis was formulated. The psychological and pedagogical aspects of preparing for interdisciplinary integration in educational robotics were also studied.*

*At the second stage, a exploratory experiment (2021-2022) was conducted.*

During this phase, the theoretical foundations of the project-based learning method for educational robotics courses were identified, and a prototype of the TiR (Training in Robotics) mobile application and educational platform for teaching educational robotics was developed and tested. The methodology for studying educational robotics was refined and further developed.

In the course of the experimental research, based on the results of interviews and surveys, the selection and development of a mobile application prototype were carried out, which aimed to modify and supplement the educational and methodological support for educational robotics courses.

*The final stage of the research was the formative experiment (2022-2023), the main goal of which was to assess the effectiveness of the developed prototype of the TiR (Training in Robotics) mobile application and educational platform, as well as the methodology for studying educational robotics. The experimental and theoretical results were processed and summarized, the findings were formulated, and the dissertation was completed (formative experiment).*

The essence of the formative experiment involved the implementation of the prototype mobile application and the TiR (Training in Robotics) educational platform, along with its methodology, in the study of educational robotics.

### **Approbation of the results of the dissertation and publication**

The main provisions and results of the research were discussed at international scientific and practical conferences: «Scientific Collection Interconf, №120 August, 2022, Recent Advances in Global Science. (Vilnius, Lithuania 2022)», «Scientific Collection «InterConf», (153): with the Proceedings of the 2nd International Scientific and Practical Conference «Society and Science: Interconnection»» (Porto, Portugal 2023), and «Future Generations: Practice and Prospects of Science and Education» dedicated to the 50th anniversary of Zhetysu University (Kazakhstan, Taldykorgan, 2023).

The implementation of the results of the dissertation work is confirmed by the certificate of copyright intellectual property, acts on the introduction of elective courses in the educational process of bachelor's and master's programs of Zhetysu University named after Ilyas Zhansugurov and the Faculty of Science and Technology of the Caspian University of Technologies and Engineering named after Sh. Yessenov.

The scientific research of the dissertation is reflected in the following publications:

1. Auyelbek, M., Ybyraimzhanov, K., Andasbayev, E., Abdykerimova, E., & Turkmenbayev, A. (2022). Analysis of studies in the literature on educational robotics. *Journal of Turkish Science Education*, 19(4), 1267-1290, <https://doi.org/10.36681/tused.2022.174>;



2. K.T. Ybyraimzhanov, E.S. Andasbayev, M.A. Auyelbek. Application of educational robotics in the pedagogical process. Series "Pedagogical Sciences", №2(70), 2021, <https://doi.org/10.51889/2021-2.1728-5496.12>;

3. Auyelbek M.A., Senkina G.E. Pedagogical potential of collaboration between educational robotics, physics, and computer science in the context of ICT. Series "Pedagogical Sciences", №3(75), 2022, <https://doi.org/10.51889/9653.2022.13.36.015>;

4. Senkina G.E., Auyelbek M.A. Pedagogical aspects of teaching robotics based on online simulators. Series "Pedagogical Sciences", №2(74), 2022, <https://doi.org/10.51889/2022-2.1728-5496.14>;

5. Auyelbek M.A., Ybyraimzhanov K.T., Auyelbekova B.A. Application of online simulators in the study and teaching of educational robotics. Scientific Collection InterConf, №120 August, 2022, Recent Advances in Global Science, Vilnius, Lithuania, 16-18.08.2022, (120), 56–62. Retrieved from <https://archive.interconf.center/index.php/conference-proceeding/article/view/1104>

6. Application of educational robotics in teaching physics. Proceedings of the international scientific and practical conference dedicated to the 50th anniversary of Zhetysu University «Future Generations: Practice and Prospects of Science and Education», 378–382, 2022;

7. Auyelbek M.A., Ybyraimzhanov K.T., Auyelbekova B.A. Psychological and pedagogical problems of educational robotics. Scientific Collection «InterConf», (153): with the Proceedings of the 2<sup>nd</sup> International Scientific and Practical Conference «Society and Science: Interconnection» (May 6-8, 2023; Porto, Portugal) by SPC «InterConf», Kramer, 2023. 385 p. ISBN 978-989-20-0402-0 (series);

8. Alimov A.K., Auyelbekova B.A., Auyelbek M.A. Innovative Technologies in Higher Education. Textbook – Taldykorgan, 2022. – 144 p. ISBN 978-601-216-791-7;

9. Certificate of registration of intellectual property rights. Object type: scientific work. Object title: Innovative Technologies in Higher Education, Textbook № 22776 dated «December 31, 2021»;

10. National Center for State Scientific and Technical Expertise. State registration number №0123PKH0085, outgoing number №3. Project title: TiR (Training in Robotics) - mobile application for robotics education;

11. Certificate of registration of intellectual property rights. Object type: software. Title: TiR (Training in Robotics) - educational platform for teaching robotics, №42944 dated «February 15, 2024».

**Structure of the Dissertation.** The dissertation consists of an introduction, two chapters, a conclusion, a bibliography of the used literature, and appendices.

*The introduction* substantiates the relevance of the problem, defines the object, goal, hypothesis, objectives and methods of the study, formulates the contradiction underlying the research problem, reveals the leading idea, scientific novelty, theoretical and practical significance, determines the methods and provides the provisions to be defended.

*The first section* «Theoretical foundations of the study of the typology of educational robotics» analyzes educational robotics as an object of interdisciplinary discourse. The psychological and pedagogical features of preparation for interdisciplinary integration are updated, namely from the point of view of a set of tools and methods, as well as mental manifestations in the process of educational activity. Based on the latest data, the prerequisites for training future teachers of physics and computer science to teach robotics in elective courses have been determined.

*The second section*, «Specifics of the methodology of teaching educational robotics at a university in the context of a modular approach», presents a methodology for organizing the training of future teachers of physics and computer science to teach educational robotics based on a project.

*At the conclusion* of the dissertation, the results of the research are summarized and the main conclusions are presented.

**List of sources used:** in the process of conducting the dissertation research, sources consisting of 213 titles were used.

The appendix contains the material developed during the research, which is not included in the dissertation work, acts of implementation and author's certificates.