

# Developing Pupils' Learning and Research Skills on the Basis of Physical Experiments

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**Abstract--***This article was written with the aim of to develop a methodological system for the development of educational and research skills based on physical experiments in students of the academic lyceum in the direction of exact sciences. Research objectives: studying the development of educational and research skills in students as a pedagogical problem based on the analysis of pedagogical and scientific-methodical literature, developing the theoretical foundations of a methodological system for developing educational and research skills in students and its model; coverage of the pedagogical and psychological conditions of the teacher and student in the process of developing educational and research skills in students and assessing the level of development of educational and research skills in students; development of an optional course program for the development of educational and research skills in students based on physical experiments; development of recommendations on the use of mathematical models and programs, modern educational technologies in the implementation of educational research aimed at the development of educational research skills in students.*

**Key words--***learning skills, physics, media resources, special tasks, physics training, case studies.*

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## I. INTRODUCTION

The current stage of development of society is In the context of the development of world education, changes in scientific knowledge and its paradigms, the exact sciences, in particular the subject “Physics”, are considered as a multifactorial phenomenon that affects the development of the intellectual potential of a person. The widespread use of mathematical calculation methods and information and communication technologies, interdisciplinary scientific searches, the complication of the technical and physical experimental base, and the globalization of urgent fundamental problems (for example, the Large Hadron Collider) in research in physics require the training of modern competent researchers working in collaboration. As an important factor in the formation of the information and educational environment that contributes to the development of the individual's creative abilities on a global scale, it is necessary to improve modern didactic tools, forms and methodology for preparing, organizing and conducting physical experiments aimed at developing activity, research, creativity, research abilities of students. At the same time, the issues of applying interactive education methods in teaching physics, integrating traditional and modern methods of teaching physics, and equipment based on information and communication technologies are becoming more relevant. gradual improvement of the technology of educational and research skills in students.

In our republic, surveys are being conducted to improve and optimize the methods of teaching physics in

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institutions of continuing education, and the use of interactive pedagogical technologies in the learning process. The Strategy for Action on Five Priority Areas of Development of the Republic of Uzbekistan defines as a priority the task “further improvement of lifelong education, increasing the possibility of quality educational services, continuing the policy of training highly qualified personnel in accordance with modern requirements of the labor market”. In this area, there is a need to train competent personnel able to compare, analyze, generalize scientific facts, find optimal solutions, independently make decisions in problem situations, conduct systematic research and implement positive results in practice in the context of computerization and globalization of education, science integration, education and production.

## II. METHODOLOGY

Objective: to develop a methodological system for the development of educational and research skills based on physical experiments in students of the academic lyceum in the direction of exact sciences.

### Research Objectives:

- the study of the development of educational and research skills in students as a pedagogical problem based on the analysis of pedagogical and scientific-methodological literature, the development of the theoretical foundations of a methodological system for the development of educational and research skills in students and its model;
- coverage of the pedagogical and psychological conditions of the teacher and student in the process of developing educational and research skills in students and assessing the level of development of educational and research skills in students;
- development of an optional course program for the development of educational and research skills in students based on physical experiments;
- development of recommendations on the use of mathematical models and programs, modern educational technologies in the implementation of educational research aimed at the development of educational research skills in students.

As an object of study, the development process of educational and research skills based on physical experiments in students of the academic lyceum is outlined, for experimental work involved 504 students of academic lyceums at the Tashkent University of Information Technology, the Tashkent Institute of Irrigation and Agriculture Engineers, Andijan State University.

The subject of the study is the development of educational and research skills based on physical experiments in students of the academic lyceum in the direction of the exact sciences: forms, methods, means and ways.

Methods of research: When performing research work, methods of analysis of educational and methodological and scientific and methodological literature, observation of the process of performing educational and research work, forecasting the level of development of educational and research skills, quantitative and qualitative analysis of mathematical and statistical analysis of the results were applied.

### **The scientific novelty of the study:**

- a methodological system for the development of educational and research skills through the introduction of modern pedagogical technologies (aimed at the personality based on the activity of cooperation, problem search) aimed at the development of educational and research skills of students and elements (motive, activity, research, convergent and divergent degrees of thinking, cognitive and creative qualities in cognition) learning activities;
- on the basis of the development of a complex of didactic elements (consistency, consistency, visualization and functionality), educational processes (individual work, assembly of an experimental device, comparison and analysis of results) aimed at the development of educational and research skills of students have been improved;
- the content (research problem, research idea, research method) and the organizational structure of the development of educational and research skills in students on the basis of systematization of experimental (creative, research) tasks on didactic features and the priority of dynamic characteristics of intersubject communication have been improved;
- improved on the basis of the introduction of teaching materials (mathematical models, ICT programs and an optional course program), educational and methodological support for the organizational and practical processes of educational research based on physical experiments.

### **The practical result of the study is as follows:**

A curriculum and curriculum of an optional course designed to develop educational and research skills of students were developed and their implementation in practice was recommended;

methodological manuals entitled “Laboratory and demonstrative experimental work in physics”, “Conducting laboratory work in physics in secondary specialized vocational educational institutions” designed and developed in the educational process for students of the academic lyceum in the field of exact sciences were developed and implemented in the educational process ;

designed and implemented in practice tasks, methodological and didactic materials aimed at the development of creative thinking and educational and research skills of the student.

The reliability of the research results is determined by the basis on regulatory documents, methodological approaches, methods and theoretical data from official sources, the validity of analysis and effectiveness, pedagogical experimental and educational work through mathematical and statistical methods, the mutually compatible goals and objectives of the study, the implementation of recommendations in practice and approval of the results by competent organizations.

## **III. LITERATURE SURVEY**

In our republic, in the countries of the Commonwealth and in foreign countries, a number of research works have been carried out to improve the educational system and increase the creative abilities of students. Research work carried out by scientists of our republic, in particular A. Avlekulov [3] - preparing students for a thought experiment, the scientific works of M. Kurbonov [7], S.Yu. Makhmudova [9] and Kh. Kh. Tozhiboeva [18] are devoted to the expansion of the methodological functions of a physical experiment. And in the research works of B.N. Nurillaev [11] and D.A. Begmatova [5], metological recommendations were developed to increase the

content and overall quality of education through a workshop in physics. However, in the research work of scientists of our republic, the problems of the development of educational research activities of students are not sufficiently studied.

The following research works were carried out by Russian scientists: V.G. Razumovsky [16] - on the development of students' creative abilities, A.V. Usova [19] - on the formation of scientific concepts in students in the learning process, A.I. Savenkov [17] - on the development of research ability in students, A.V. Khutorsky [6] - on the technology of creative learning, A.M. Matjushkin [10] - by the importance of creative research in education, N.G. Alekseev [1], A.V. Leontovich [1,8], A.S. Obukhov [1, 12], L.F. Fomina [1] - according to the concept of developing research activities of students, A.N. Poddyakov [14] - according to the methodological foundations of the development of educational and research activities, T.V. Avgustmonova [2], O.G. Prokazova [15], O.L. Bajzulaeva [4].

To improve the teaching and research skills in the process of training by psychologists from foreign countries (P.Guilford [13]), research was conducted on the psychophysiological characteristics of the creative process of students (emotionality, degree of mental activity at various phases of the creative process, intuition ).

#### **IV. THEORY AND DISCUSSION**

At present, educational paradigms are changing - a transition is being made from the learning process aimed at bringing to students accurate knowledge in a certain amount, to a new direction in learning, those to "learning to learn." The need for such a transition was discussed in the psychological and pedagogical works of many scientists, such as A.V. Leontovich, A.N. Poddyakov, A.S. Obukhov, A.V. Khutorsky [1]. research activity ”; “ educational research work ”; “ research ability ”; “ research skill ”. In the general educational field, the content of the term educational research is reflected in the content of the activity, in the definition of education. If this activity in the research work ends with one new result, then in the research work the development of the intellectual abilities (and mental activity) of the student is considered as the main goal.

Based on the analysis of the views of A.V. Leontovich [8], A.V. Khutorsky [6], and others, as well as the definition of research skills in the “Explanatory Dictionary of the Uzbek Language”, the following conclusion was drawn - in psychological and pedagogical literature there is no consensus on the composition of research skills. Summarizing the opinions of scientists - psychologists and educators - we determined the research ability as follows: when it comes to research skills, it is necessary to understand the ability to effectively carry out activities using scientific research methods. The development of research skills is carried out at all stages of activity on the basis of the conscious integrative application of knowledge obtained in various subjects.

Studying and analyzing the real situation of preparing students of the academic lyceum for educational research activities and developing their educational and research skills based on physical experiments showed that this is considered a systemic personal quality. Personal research quality is assessed not only by knowledge, skills, but also includes motive, interests, search, experience and personality values.

The specificity and nature of educational and research skills is reflected in the content of training, and the level of its development is considered the result of the didactic process. In solving the problems of the development of factors affecting the development of educational and research skills in students, the development

of educational and research skills in them based on physical experiments, the pedagogical and psychological ideas of A.I. Savenkov [17], is suitable for our research work.

Based on a review of the literature, factors were studied that influence the development of educational and research skills in students based on physical experiments. The first factor is the basis of the research work. Clarification of the content (scientific, systematic, consistent, accessible, age-related abilities and capabilities) necessary for the development of educational and research skills in students related to research; the second factor is organizational and pedagogical influence. The composition of this factor includes the following: teaching methods (conversation, solving creative and experimental problems, laboratory exercises, demonstration experiments related to cognition), the organization of educational and research activities (individual or group), educational devices and educational tools, information support, control and verification of results and requirements for teachers (organizer's abilities, communicative skills, research, scientific knowledge); the third factor affecting the effectiveness of the didactic process is the level of preparedness of students (general preparation, that is, the availability of basic knowledge for engaging in educational and research activities, the formation of the ability to master educational and research skills, personal qualities, etc.); the fourth factor is time (the correct calculation of time and its productive use); the fifth factor is the material and methodological reserves of an educational institution. During training, the material security of the educational institution, the quality of management of the educational institution, and the professional qualifications of methodological teachers and each teacher are of great importance.

The implementation of an integrated approach of the above factors in the process of developing educational and research skills in students allows us to successfully develop educational and research skills in students of the academic lyceum.

When creating the methodology of the methodological system for the development of educational and research skills in students, it was determined that it consists of the following components:

- 1) elements of the process of development of educational and research skills students.
- 2) objects of the process of development of educational and research skills students
- 3) modern pedagogical technologies in the process of developing educational and research skills of students;
- 4) forecasting the level of development of educational research skills in students.

We clarify the tasks of the component of the methodological system. Such elements as target, substantive and procedural are introduced into the elements of the process. The target element in the process of developing educational and research skills in students is aimed at solving the following problems: identifying students who are interested in teaching and research work (conducting a physical experiment) and involve them in educational and research activities; on the basis of an integrated approach to the development of educational and research skills (observation, vision of a problem, setting the idea of work) increasing the student's level of ability of thinking (critical, creative, convergent and divergent); the formation of skills for solving non-standard experimental problems, the implementation of educational research work, analysis of the result of educational research work, writing a report, preparing a presentation on work, self-esteem.

The substantive element of the process of developing educational and research skills in students is aimed at

solving the following problems: the conformity of educational research works (physical experiments) performed outside the classroom, aimed at developing educational research skills, theoretical knowledge, practical exercises, and the contents of laboratory works studied in learning process; material support of the educational institution when choosing the topics of educational research work, to take into account the possibilities of performing educational research work by a student of the academic lyceum; correspondence of didactic support developed according to the substantive component of the methodological system (by the example of fulfilling tasks related to working with information and developing the level of thinking ability).

The process element of the development of educational and research skills in students consists of the following: assimilation of the elements of educational and research activities (methods of scientific knowledge, physical experiment and its types, analysis and synthesis, educational research, research hypothesis, research method); the process of developing skills in working with information (the search for the most important information for research work, the effective use of the data obtained in the work process); the process of development of creative thinking (the ability to apply the supporting knowledge obtained in performing experimental tasks); preparation for the experiment (familiarization with the basic principles of research, drawing up a work plan for research, identifying the instruments necessary for the experiment, familiarizing yourself with the method of the experiment, conducting the experiment independently); development of the ability to write a report on educational research work (mastering the procedure for designing research work, processing the data obtained through the experiment and entering the received data into the report); development of the skills of the presentation of educational research work (working with information sources, the importance of the data obtained during the experiment and the use of mathematical models and ICT programs at work, the ability to use ICT tools during the presentation).

The component of forecasting a methodological system is based on the following criteria: attitude to educational and research activities (cognitive - knowledge of working with the information received, the sequence of the experiment and the organization of work); motivational (interest in conducting research and understanding the essence of the phenomenon); mastering the methods of scientific knowledge (scientific abstraction, idealization, mental models, putting forward scientific ideas and hypotheses, observing, conducting an experiment, presenting the results obtained on the basis of scientific facts, measuring, calculating, generalizing, analyzing, synthesizing, conclusions); assimilation of research concepts (research problem, research idea, research method); attitudes toward obtaining research data (from various textbooks, reference books, and the Internet system); development of the level of creative thinking (thought experiment, convergent, divergent, critical, creative); qualitative characteristics of the level of empirical knowledge of students on the basis of solving problems experimentally (activity, creativity); the process of conducting the experiment (design of the experiment, obtaining results); the level of processing of the obtained results and the use of ICT and mathematical models.

In the process of organizing educational and research activities for students, the following modern pedagogical technologies were widely used in developed countries (USA, England, Germany, South Korea, Russia, etc.) - information development technology (cognitive, "related to cognition"); learning technology based on the activities of cooperation, learning technology aimed at the individual, developing problem-search technology. These educational technologies have a positive effect on students' motivation for research and

development, search activity, cognitive and creative qualities.

The objects of the process of developing educational and research skills in students consist of the following components: cooperation between a teacher and a student, material and technical support of an educational institution, and methodological support of an educational institution. The process of conducting an optional course is also considered a procedural component of the methodological system, i.e. the teacher in the process of conducting classes constantly monitors the development of educational and research skills in students.

With the practical implementation of the methodological system for the development of educational and research skills in students, the optional course “fulfills the task of a fixed asset. Through this course, tasks such as awakening the motive for students to do research work are carried out; preparing students for the implementation of educational research and development of educational research skills; definition of educational research based on the principle from simple to complex, phased development of educational research skills of students.

## **V. EXPERIMENTAL RESULTS**

The following conditions have been identified as the main conditions for the organization of pilot testing:

determination of the content of the development of educational and research skills in students based on physical experiments;

The organization of the phased development of educational and research skills in students based on physical Experiments;

Conducting an experimental test of the optional course "Development of educational and research skills in students based on physical experiments" prepared in the process of this research work; assessment of the level of development of educational and research skills in students.

The goals and objectives for the first stage of the experimental work (the formation of research activities) are defined. As methods for assessing the level of development of educational and research skills, students prepared questionnaires, tasks of a creative nature, applied experimental problems and physical experiments.

At the second stage of experimental work (2015–2017), which was considered the stage of research, it is planned to develop a methodological system for the development of educational and research skills in students of the academic lyceum. At this stage of the pilot test, an optional course “Development of educational and research skills in students based on physical experiments” was created, for which academic lyceums at the Tashkent University of Information Technologies (TUIT), the Tashkent Institute of Irrigation and Agricultural Mechanization Engineers (TIIMSH), Andijan were selected State University (AndSU).

At the stage of research experimental work, the material and technical support of the educational institutions in which the experiment will be conducted was first studied. The material security of educational institutions (laboratory training devices and means of information communication) formed the topic of educational research. The factors affecting the educational and research activities of students are studied. A methodology for the implementation of educational research has been developed. The estimated composition (practical and intellectual) of educational and research skills of students is determined. Based on the results of decisions by students of creative tasks, the levels of their convergent and divergent thinking were studied (out of 504 students

at the beginning of the observation, 24.8% - convergent, 6.7% - divergent; at the end of observation, 44.6% - convergent, 13.7% - divergent). By the solution of experimental problems by the students, the presence of research activity and dynamics of changes was established in them (Table I).

**Table I.** The results of the study of the levels of convergent and divergent thinking of students

Level of thinking	Academic Lyceum TUIT (162 students)		Academic Lyceum TIISH (163 students)		Academic Lyceum of AndSU (179 students)	
	at the beginning of the experiment	at the end of the experiment	at the beginning of the experiment	at the end of the experiment	at the beginning of the experiment	at the end of the experiment
Convergent	45	74	43	87	37	64
Divergent	12	26	11	23	11	20

In determining the estimated structure (practical and intellectual) of research skills in students at the third stage, the stage of determining the development of educational and research skills in students on the basis of physical experiments was completed. A mathematical and statistical analysis of the experimental work was carried out and the results were generalized. The indicators of assimilation of the control and experimental groups are given in table. II.

**Table II.** Indicators of assimilation of control and experimental groups

Abilities	Experimental group (255 respondents)				Control group (249 respondents)				T
	Experience time	Q <sub>11</sub> high	Q <sub>12</sub> mid	Q <sub>13</sub> low	Experience time	Q <sub>21</sub> high	Q <sub>22</sub> mid	Q <sub>23</sub> low	
Practical	At the beginning	16	58	181	At the beginning	13	59	177	
	In the end	29	109	117	In the end	16	82	151	11,82
Intelligent	At the beginning	11	34	210	At the beginning	9	34	206	
	In the end	19	67	169	In the end	11	41	197	10,46

In the statistical analysis of the pedagogical experimental work carried out, the method of  $\chi^2$ -statistics was applied to them. These hypotheses are tested based on the formula  $T = \frac{1}{n_1 n_2} \sum_{i=1}^c \frac{(n_1 O_{2i} - n_2 O_{1i})^2}{O_{1i} + O_{2i}}$   $\chi^2$ -statistic criterion. Since in the research work for the level of freedom there was a class digit  $\chi = 2$  and  $i = 1.2.3$  ( $c = 3$ ), and the level of significant deviation was 0.05, we took the value  $T_{cr} = 5.991$ , obtained from the table of the coefficient value of the Pearson criterion; it is determined that the value of  $T_{nab}$  calculated by the method "Chi-square", in all cases  $T_{cr} < T_{nab}$ .

As a result of the implementation of the optional course "Development of educational and research skills of students based on physical experiments" in academic lyceums in the direction of exact sciences, students achieved practical skills increased by 5.1% and intellectual skills by 3.2%.



## VI. RECOMMENDATION AND CONCLUSION

Based on scientific and methodological studies conducted on the topic "Development of educational and research skills in students based on physical experiments", the following conclusions are made.

1. From the point of view of the theoretical aspect, it is substantiated that the methodological system for the development of educational and research skills in students consists of the following components: a model of pedagogical activity for the development of educational and research skills; forecasting the level of development of pedagogical technologies and objects, as well as educational and research skills in the process of its development.

2. To increase the effectiveness of training in academic lyceums, the necessity of introducing into practice a methodological system for the development of educational and research skills in students through the optional course "Development of educational and research skills in students based on physical experiments" has been substantiated.

3. Through physical experiments based on the use of educational technologies aimed at the personality, it was determined that attracting students to research activities, the stages of their preparation for the implementation of educational research work and the development of their research skills are an effective method of developing educational and research skills in students.

4. It is determined that the development of educational and research skills of students is based on the principles of consistency, intersubject integration, creative activity and assessment of their activities.

5. It is determined that activities aimed at the formation and development of educational and research skills based on physical experiments become the basis for students to learn some elements of research and development and develop cognitive and creative qualities in them.

6. Using the mathematical statistical method, it is determined that, as a result of the implementation of the "Methodological System for the Development of Educational Research Ability of Students Based on Physical Experiments", practical and intellectual skills increase in academic lyceums in the direction of exact sciences.

### **Practical recommendations for the development of educational and research skills in students:**

a) the use of a methodological system for the development of educational and research skills of students on the basis of physical experiments in preparing students for educational and research activities in teaching physics in specialized educational institutions of the republic in exact sciences is proposed;

b) it is proposed to conduct 12-hour training sessions on the topic "Involving students in educational and research activities" in regional centers for retraining and advanced training of public education workers;

c) the introduction of "Educational and research activities at school" in higher pedagogical educational institutions was proposed as a selective subject.

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