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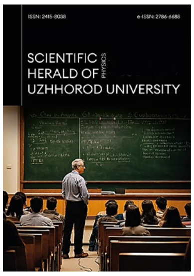

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The development of research skills in physics laboratory works of secondary school students in an information and education environment

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Abstract

Relevance. The relevance of this research lies in the indispensable role of laboratory work in physics education. Laboratory sessions facilitate the integration of knowledge, research, and practical skills, fostering essential qualities such as independence, analytical thinking, and the application of theoretical concepts to real-world situations. As comprehensive schools evolve, there is a growing need to employ laboratory work to enhance students' independence, adaptability, and creative problem-solving abilities in physics. Laboratory work is a critical method for developing research skills and occupies a leading position in organizing activities that develop complex skills.

Purpose. The purpose of this study is to analyze the relevance and feasibility of using mobile technology in physics laboratory work, considering current societal and technological advancements. The study aims to explore how contemporary information learning tools can enhance the cognitive and thinking functions of students and establish an interactive dialogue for effective information perception.

Methodology. The research uses analytical methods to explore integrating mobile technology in physics labs.

Results. The study finds that the comprehensive application of technical tools, in combination with traditional laboratory and demonstration equipment, can introduce new didactic possibilities. These possibilities are currently underdeveloped but hold significant potential for enhancing interactive interaction within the information and educational environment.

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The use of mobile technology in laboratory work motivates students and ensures a more engaging and effective learning experience.

Conclusions. The research concludes that mobile technology in physics labs is an effective alternative to traditional methods. It creates an engaging learning environment, bridging the gap between theory and practice, and enhances student motivation, critical thinking, and problem-solving skills. The study highlights the importance of innovative teaching methods in modern education.

Keywords: laboratory work; physics; smartphone; mobile applications.

Introduction

As part of the priorities for the development of education and science in Kazakhstan, significant work is being done to update the content of education, the purpose of which is to improve the quality of education in educational institutions. Their renewal measures are oriented towards the formation and development of skills that have a wide range of applications in modern life, such as: creative use of knowledge and skills, critical thinking, development of language communication methods, working in a group and independently, and the implementation of research work. These skills, which are based on universal values, allow solving both learning and life challenges. In order to comply with the requirements of the typical curriculum of the renewed content of basic secondary education in the state, practising teachers use active project-based and exploratory teaching methods. However, this is due to the fact that the updated modern physics curriculum is multidisciplinary and research-oriented for students [1].

In physics lessons, pupils should not only acquire the initial knowledge of project work that is required for further study in various school disciplines but also increase their erudition, horizons, and self-confidence. However, most physics teachers mention that about 60% of pupils are unable to independently propose and justify hypotheses, develop an activity plan, consider an objective, research and analyse necessary information, conduct experiments, compare available data, and conduct reflection and report correctly. The reason is that they are compelled to work according to the algorithm imposed by the teacher, without prior preparation, and without the basic knowledge and skills that define the nature of the current process. Preparation for this type of activity is necessary for physics lessons. Laboratory work is crucial in the development of research skills as it allows you to think, discuss and solve real-world problems. In teaching, laboratory work refers to an activity that is based on observations and experiments performed by students [2].

Recently, the application of modern technology in teaching laboratories has encouraged the development of new models of learning. Due to the high availability of low-cost mobile devices, smartphones, and tablets, as well as access to internet technology, it is possible to conduct complex experiments for educational purposes not only in specialised conventional laboratories but also at home. This opportunity provides unexplored and highly effective opportunities for experimentation for both students, including those with disabilities, and teachers themselves. The scepticism associated with the application of smartphones in learning should be overcome by students' enthusiasm and improved learning results. Since interactivity in laboratories is essential in developing a productive educational environment and is crucial for evaluating the effectiveness of didactic strategies. According to the availability of learning tools, there is a change in the responsibility to explore the educational implications that emerge from technological scientific practices [3-5].

Improved information management processes have a positive impact on the pace of its cultural, scientific, and technological progress. The various transformations multiply this effect by putting each subject of activity in the strategy of the modern educational process. In physics lessons, they not only conduct experiments of all kinds but also collect, record, and analyse data. The determination of errors allows the identification of factors that affect the laboratory experiment and the best ways to improve it. This allows exploring the research route yourself and reaches a definite conclusion. It is worth noting that the existing research questions in this study are focused on practical examples of the use of smartphones in the learning process, in particular in physics teaching. The effectiveness of mobile apps in developing or enhancing specific learning skills is rarely considered [6]. The purpose of the current study is to analyse the relevance and feasibility of using mobile technology in physics laboratory work, based on current developments in society and information technology.

Materials and Methods

The methodological basis of the research was the following approaches to the study of this topic: interviewing, observation, experiential learning, and comparative experimentation. In order to identify the necessity of involving secondary school students in laboratory and research activities, a survey was conducted with 35 teachers and 260 students in Taldykorgan, which included open-ended and closed-ended questions. It was based on the interpretation of the basic hypotheses into the language of questions and was prone to the deliberate method of experimental objectives, so it was open-ended. A group of questions was included in the text of the survey to elicit views on the issue under investigation. The basic requirements were followed in the design of the survey. Consequently, it has been suggested that one of the reasons for the low level of interest in research in physics teaching is the low level of independence in conducting experimental activities. The results of the survey of teachers and students of several schools in Taldykorgan in the Republic of Kazakhstan have demonstrated the following: 83% of teachers assume that it is necessary to involve students in learning and research activities; about 70% of teachers believe that the process of inclusion of students in learning and research activities is influenced by the equipment of teaching laboratories; 65% of students would like to engage in such activities when studying the subject.

The experimental data were processed by mathematical-statistical methods. To identify the effectiveness of data integration from mobile apps and devices in physics lab work, an experiment was conducted among 9th-grade students at a school in Taldykorgan. The experiment identified the difference between the performance of students in the control and experimental groups and assessed the significance of the difference in these indicators according to the "Chi-square" criterion. The statistical hypothesis of non-random differences in the results of the answers to the questions was tested at the 0.05 significance level. Two independent samples were available and the students' level of mastery of research skills was compared. This paradigm emerged as a calculation of agreement between the empirical distribution and the theoretical hypothesis to test the null hypothesis. The critical value of the criterion is T=7.815. If the value of the criterion based on the experimental data is greater than the critical value, the null hypothesis that integrating the use of mobile applications and traditional laboratory devices does not affect the development of students' research skills is rejected and the alternative hypothesis is accepted. With the introduction of mobile app technology and conventional laboratory devices, there is an expectation of higher levels of research skills development at the time of certain activities. To determine the level of their formation, experimental skill levels were used.

In studying the problem of developing the research skills of secondary school students in physics laboratory work, a comparative approach was also used, which followed the learning process in establishing the students' experimental activities. Particular attention was paid to their activity, comprehensiveness, and appropriateness. The results of the observations were documented in a certain way at all stages of the ongoing process. In addition to observations, control experimental works were identified, which established the composition of the developed skills and their levels of assimilation according to the specific classification of R. Mayer [7]. Based on the results of the laboratory work, the number of subjects who accomplished a particular objective was counted. The results of the survey of teachers and students identified the following activities as particularly demanding in skills development: defining the purpose of the experiment, setting the research objective, formulating the hypothesis, planning the experiment, converting data from one format to another, establishing a pattern, presenting a conclusion based on the evidence, evaluating the practical aspects of the experience and the data collected, making suggestions for changing or extending the study to increase the reliability of the data.

Results and Discussion

Informatisation and the development of society in all spheres of activity have a direct impact on the younger generation and the learning process. Various problems of creativity and communication problems occur. Modern innovations demand the necessity to improve the teaching process in educational institutions and to explore different ways of teaching, including physics. To develop research skills, a process of effective implementation of laboratory work in an information and education environment is implemented in order to successfully design models of methodological development. Methodological manuals, complete with supplied equipment, identify inefficiencies and low levels of laboratory work, which cause teachers to adopt new tools and mechanisms of impact. Therefore, educational institutions have now started to consider more carefully the factors on which the success of education depends. An important aspect that affects pupils' research activities is the educational environment. It is a comfortable atmosphere that involves the personal qualities of the teacher, various extracurricular activities, and opportunities for informal communication between teacher and pupils [2].

General education schools establish a safe and friendly environment for laboratory work based on individual abilities and requirements. The most important purpose is the care for the pupil's cohesive physical, cognitive, emotional, social, and moral development. Experiential education strives to: introduce the world of values, including self-sacrifice, cooperation, solidarity, and altruism; develop competencies such as creativity, innovation, and enterprise; develop skills in critical and logical thinking, reasoning, argumentation, and inference; expose the value of knowledge as a basis for skills development; enhancing students' cognitive curiosity and motivation to learn; comprehensive personal development by expanding knowledge, satisfying and awakening natural cognitive curiosity; developing an open attitude towards the world and others, social and collective responsibility; encouraging structured and informed self-education on the ability to prepare a workshop or class for an experiment independently.

Through research activities, the school develops pupils' competencies and ensures that they have the knowledge and skills to grasp phenomena correctly and understandably, using methods and techniques borrowed from computer science and other modern subjects, including logical and algorithmic reasoning and programming, the use of computer applications, searching for and using information from various sources, using a computer and basic digital devices and applying these skills in the classroom, including performing calculations, processing information and presenting it in different forms. Conscious responsibility in the choice of resource use, critical analysis of information, and safe movement in the digital space support respectful relationships for each pupil according to his or her requirements and abilities. The identification of forms of individualised learning should be based on the recognition of potential. As long as the teacher allows pupils to succeed to the best of their ability, they have a chance for general educational development. Consequently, he/she should design objectives so that, on the one hand, they do not exceed the possibilities and, on the other hand, do not lower the motivation to solve problems in the current subject [8; 9].

Laboratory work in physics is an area in which you should be prepared to accomplish learning objectives. Practical lessons should be based on examples from everyday life and an active study of physical phenomena and processes. The emphasis should be on the ability to identify processes, knowledge of their conditions of origin and course. An important element is the development of skills through the construction of correct cause-effect relationships. Effective calculation and quantification are a special experience that cannot be considered as a major learning objective. Students should develop the ability to evaluate critically the results obtained. Teamwork encourages social competence, initiative, and enterprise for maximum effect. The following conditions are necessary for a productive group study: setting general purposes, establishing clear decision-making rules, using resources and involving each student, exchanging information accurately, improving and developing team members in the area of objectives, processes. Individual experiments are mostly limited by the absence of the required amount of equipment, space, and time. The laboratory study can be seen as a collection of suggestions for teacher implementation.

The Innovative General Education Programme in Physics includes a variety of methods for working with pupils that can be useful in implementing selected issues contained in the curriculum related to the specified project. Whether it is information or not, each teacher has to implement his or her idea to make the chosen issues or phenomena a reality. After all, the effect of the learning process depends to a significant extent on the proper organisation. Active learning methods should predominate in physical education, as they stimulate activity and encourage creative thinking and group work skills. In order to achieve the objectives designed at the time of the laboratory work, appropriate teaching methods and techniques are required. Individual methods should not be mutually exclusive, they should complement each other [10; 11]. One method is not effective by itself, it is important to support and complement it with others so that the experience is complete and correct. Many factors affect the choice of techniques. These may include objectives, content, didactic tasks, group size, time, place, and didactic skills of the teacher.

Without a combination of different methods of scientific investigation, observation allows only the external properties and features of objects and phenomena to be explored. More detailed knowledge can only be gained through theoretical and experimental means. The theoretical way involves analysing specific facts that are observed and perceived from the perspective of the relevant theories and which predict the course of observed events. The experimental method involves observing a phenomenon under considered conditions, which makes it possible to establish cause-effect relations between characteristic quantities and qualities of objects. It constitutes an important practical aspect, which acts as a genuine criterion for distinguishing results. The current method proceeds by purposefully intervening in the process under study, appropriately modifying the object, and reproducing it under specially created conditions. For this reason, experimentation is one of the primary communication tools between science and pupils. Its widespread use in school instruction helps to develop a proper understanding of the characteristics of a scientific physical experiment and the essence of cognition of this method. The importance of practical experimentation is growing, which is justified by the requirements of the state regional concept for the development of education. Laboratory work in physics in an information and education environment effectively consolidates theoretical knowledge, convincing students that the world is perceptible and material. In addition, such activities make pupils feel a part of obtaining scientific facts, encouraging them to become the product of their thoughts, which influence and arouse emotions specific to the ongoing process. Frequently, learning laboratories remain unprepared for suitable and immediate usage. In addition, they do not contain all the necessary devices, the physics laboratory computers are not equipped or not accessible at all, and the required infrastructure and specialists to establish and manage the laboratories for safe experiments are not provided. In such cases, the use of computer lab types can assist with many of the upcoming tasks. Well-designed microcomputer-based laboratory devices assist in focusing on the scientific ideas that are the purpose of their research. It improves learning by widening the range of studies, can be used by newcomers, and promotes critical thinking skills to diminish tedious data collection. Microcomputers are an effective tool for teaching untrained students how to design all kinds of graphs [12; 13].

The theoretical material indicates the knowledge and practical experience requirements for the objectives of the laboratory work, establishing an understanding of its content. The practical work includes the basics of the theoretical part of the physics subject in the absence of textbooks and summary information, which is necessarily complemented by specific formulas, drawings, examples, or diagrams. The methodological guidelines identify a sequence of techniques and mechanisms that ensure the processing and execution of empirical material for a comprehensive analysis. The possibilities for obtaining knowledge are varied. In physics learning in an information and education environment, one of the primary ways of obtaining new skills is through laboratories. In the learning process, it provides the opportunity to obtain data that is impossible in conventional circumstances, allowing you to focus on the essence of the experiment and explore the creative abilities of your students [14; 15].

The laboratory work is a sequence of instructions provided by the teacher and a specific plan for determining the vector of observation, which develops an understanding of the uncomplicated making of discoveries. The ability of pupils to implement scientific knowledge in everyday life should be a priority for every teacher. However, practice proves that it is not always possible to understand the cause-effect relationship in the processes that occur, which causes so much difficulty in combining knowledge with practical activities. The main reason for innovation is to encourage students to develop an interest in physics, to develop creative inventions, to explore questions and answers, to observe and understand the cause-effect relationship between physical phenomena, and to encourage new initiatives to test their abilities in practice [16; 17]. The various activation methods and didactic tools used to facilitate the understanding of phenomena and develop creative thinking and appropriate attitudes. Physics experiments allow them to better understand the world around them. Pupils develop into discoverers of laws and principles, encouraging their natural curiosity about the world and an entrepreneurial attitude to enter the demanding labour market in the future.

By integrating mobile technology with a well-designed curriculum enhances student engagement, productivity, technological competence, collaboration, innovation, and critical thinking [18]. By establishing an engaging learning environment through mobile application development, interest in computing and information technology is significantly increased. Smartphones are cheaper and more powerful every year, becoming extraordinarily popular among young people. Mobile learning is more than just an intellectual use of time; it is an opportunity to expand the range of e-learning applications [19; 20]. Students can use them to design their experiments to study acceleration under different conditions or as a way of conducting quantitative experiments in dynamics. For many learning experiments, there is no necessity to buy other devices as many sensors are already included in the smartphone and can provide many measurements of a wide range of physical quantities. By combining and analysing the data, a variety of laboratory activities can be developed by adapting the experiments to the specific learning objectives and requirements of a particular group.

The number of laboratory experiments, the range of parameters measured, and the accuracy, sensitivity, and other characteristics of the sensors determine the hardware and software platform implemented. Generally, modern technology is only applied in the classroom as an auxiliary device to facilitate work or solve technical problems. In such an approach, their introduction may hamper the development of specific skills that pupils have to acquire on their own at the time of learning. There is a risk of misuse of information and educational innovations, which is why their use is not allowed in many schools because their operation is a distraction for pupils and occurs in competition with or against conventional teaching [21; 22]. Teachers should be able to integrate mobile devices and apps into the curriculum to enhance overall outcomes. On their own, tools cannot promote student engagement or productivity. Positive results in enhancing the understanding of various concepts have concluded that smartphones are no substitute for genuine laboratory work.

However, their implementation as an observational tool is a way of learning and exploiting the opportunities offered by new technologies [23]. Throughout the learning process, students in the experimental and control classes completed laboratory work using conventional laboratory instruments and mobile applications, in particular an accelerometer – a sensor that detects the angle of an electronic device relative to the ground. It indicates the acceleration of a device in space by simultaneously comparing three spatial coordinates by measuring the difference between the projections of absolute and gravitational acceleration. The experiment used the Physics Sensor application. It indicates the projection of the value of the free-fall acceleration in the Cartesian coordinate system both graphically and numerically in real-time. The sensor measures acceleration by displaying three spatial coordinate axes: X - width, Y - length, and Z - height (Figure 1).

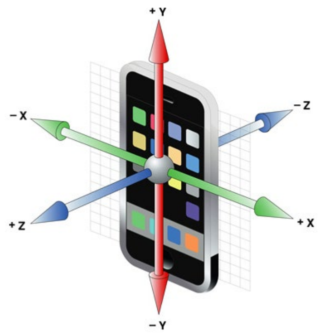

Figure 1. How the accelerometer functions

Values can optionally be recorded in MS Excel and exported via Bluetooth or email to a computer. The pupils used it to determine the value of the acceleration of the free fall during an oscillating movement. The subject chosen was the mobile phone itself. After establishing the centre of gravity of the smartphone, a 0.34m long, non-stretchy string was attached to the smartphone. Next, the device was applied in an oscillating motion along an axis and the change in gadget acceleration was measured along the three spatial coordinate axes. An essential aspect of the development of research skills is the individualised approach of students in the laboratory lessons. Account of the level of ability and interest in the subject determines the number of objectives necessary to produce a productive result. An individual approach hampers the teacher's preparation and choice of assessment methodology when implementing the objectives. Therefore, information and multimedia technology allow students to explore various physical phenomena in a more simplified way. They can substitute most conventional instruments, establishing an integrated process of knowledge acquisition. A significant role is played here by computer modelling, which is a hardware-software space that allows interactive influence on the object under study and obtaining information on the results of this influence. This form of laboratory work allows research to be conducted in a familiar computing environment with the opportunity to experiment. Due to its convenience, physics learning mechanisms become simplified and directed towards the understanding of the essence of a phenomenon. There are no reports to complete, and no time-consuming installation of equipment and its integration [24; 25].

The influence of modern electronic technology on students' creativity is explored in physics laboratory work in an information and learning environment, which allows computer-based learning to be regarded as an important trend in teaching methods. The increasing role of computerisation enables improvements in learning methodologies and tools to be implemented. This concept allows the construction and programming of computational algorithms and the use of computer modelling to interactively influence the object under study. The use of current technology in laboratory classes is emphasised by creative learning and cognitive activities and the diagnosis of user skills [26; 27]. The current process is the basis for influencing the level of skills and knowledge, as well as the development of personal qualities. However, in practice, effectively establishing the potential benefits of computers for students is still unresolved, because most physics methods textbooks do not clarify the problem of engaging students in creative research activities, but only reinforce the importance of addressing it. The development of research skills in physics laboratory work is observed during the teacher's demonstration of experiments. The description and observation of such facts are accomplished in physics workshops, observations and experiments. Analysis and comparison are the results of empirical inference based on inductive conclusions. The deductive method assists in exposing information and materials into a specific logical form of an illustrated learning experiment. Based on this, the teacher encourages the students to develop a solution to the problem and reach a proper conclusion. Then, thanks to the illustration, the consequence of the regularity or correctness of the calculation is demonstrated. This way of information presentation allows the brief information that emerges in the process of acquiring knowledge to be valid, which develops an interest in the subject and develops scientific beliefs. It requires a relatively short time and is conveniently combined during the lesson with possible theoretical aspects. With the combined form of mental and practical tenses, on the other hand, the phenomenon is not produced at all or the process occurs only partially. Pupils frequently require reliance on sensory images encapsulated in the verbal presentation [28; 29].

The most essential requirement for conducting physical laboratory work is the expressiveness of the demonstration by minimising undesirable processes that can provide a false or improper reason for interpreting a particular experience. It is essential to ensure high visibility for the students, as the demonstration usually plays to a large group at the same time. The effectiveness of an experiment relies on dependability, that is, obtaining the desired result with an exact degree of repetition and under the same parameters and conditions of display. The requirement for a vivid visual image, which is essential to the psychological attitude that develops during the explanation of new material, requires a realistic impression. However, the age and emotional factors of the students should always be considered to ensure optimal preparation for the laboratory work. The following skills are developed in this technique: designing the experience, creating the conditions for the objective, selection of materials and equipment, justification of the hypothesis, independent formulation of the purpose. During the activity in question, the educational and psychological requirements should be considered [30; 31].

With the growth of the information-education environment and the emergence of increasingly powerful mechanisms and tools for representing phenomena, the possibilities of using numerical methods in modelling the behaviour of actual systems are growing. Methodologically, a distinction is made between the substantive, functional, and institutional aspects of the activity. According to content, they are systems based on assertions and hypotheses that include scientific knowledge and socio-economic practices of phenomena, processes, and regular structures that are as objective and adequate as possible at a particular stage of development. The sum of objective knowledge about nature, society, or human beings, about the relations between them, their origins, and the regularities that govern them act as a kind of scheme of socially developed judgments about reality, verified and unverified facts. Laboratory teaching functionally covers all the activities that constitute scientific information. These are the defining actions of the results obtained, deployed against the backdrop of theorems and laws that ensure truthful knowledge of the field. When coherent content and methodological requirements are followed, organisational units of the institutional system, in the form of comprehensive schools, are developed [32; 33].

The development of pupils' research skills in schools involves promoting new methods and forms of work that allow for a degree of individualisation, which means developing a variety of approaches adapted to the requirements and abilities of the pupils engaged in the laboratory work. Physical education should be contemporary, friendly, and effective, activating curiosity and a willingness to continue learning. At all times, the pupil is obliged to express interest in the various objectives, with the teacher playing a supportive, advisory, and inspirational role. The methods proposed in the programmes are varied, relate to different learning styles, and are frequently used interchangeably. The use of active methods allows pupils to develop their own experience of basic physical concepts and operations. The basis for the arrangement of work in the implementation of the laboratory work is its preferences and requirements. The teacher should encourage participants to perform specific actions by questioning and problem-solving [34; 35].

Conclusions

Thus, there are specific differences in the types of laboratory activities that inevitably affect learning results and the development of research skills. Some laboratory classes are designed deductively, meaning pupils collect data to verify and further understand the laws previously outlined in a text or classroom. Other activities include a formal introduction to the topic being explored. In this case, the students accumulate information about materials or phenomena, from which relationships are subsequently identified, and a synthesis of the materials is provided. In addition, one laboratory work can be quite different from another in terms of the amount of guidance, as some studies are well designed and follow instructions, while others are considerably more open, involving this in the planning and design of the elements of the experiment.

Some laboratory work emphasises the manipulation of materials, while others emphasise the skills of observation, interpretation of data, or application of procedures to new problems. Consequently, such differences between laboratory work may affect learning results and the level of development of particular skills. Therefore, two types of work were considered in the current study: the integration of mobile application data and conventional laboratory devices, as well as conventional laboratory devices with specific instructions. Based on the data from the comparative experiment, it can be assumed that the complementary use of mobile applications is effective in accomplishing these objectives. It develops research skills which, in addition, are in most cases better acquired than when using conventional instruments exclusively.

In experimental activities designed using smartphones, students develop research following skills: converting data from one format to another; establishing patterns;

presenting an evidence-based conclusion; evaluating the practical aspects of the experience and the data collected; suggesting changes or extensions to the study to improve the reliability of the data. Notable, that when this method is implemented, the student's interest in the subject is enhanced and, consequently, their performance in the subject improves. The suggested method of laboratory work to develop research skills can be implemented in subject areas such as physics, biology, chemistry, and other related sciences.

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Conflict of Interest

None.

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Розвиток дослідницьких умінь під час виконання лабораторних робіт з фізики в учнів загальноосвітніх навчальних закладів у інформаційно-освітньому середовищі

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Анотація

Актуальність. Актуальність дослідження полягає у незамінній ролі лабораторних робіт у навчанні фізики. Лабораторні заняття сприяють інтеграції знань, дослідницьких та практичних навичок, і виховує такі важливі якості, як самостійність, аналітичне мислення, застосування теоретичних понять до реальних ситуацій. З розвитком загальноосвітніх шкіл зростає потреба у використанні лабораторних робіт для підвищення самостійності, адаптивності та творчих здібностей учнів до розв'язання задач з фізики. Лабораторні роботи є важливим методом розвитку дослідницьких навичок і займають провідне місце в організації діяльності, що розвиває комплексні вміння.

Мета. Метою цього дослідження є аналіз актуальності та доцільності використання мобільних технологій у лабораторних роботах з фізики з урахуванням сучасного суспільного та технологічного розвитку. Дослідження спрямоване на вивчення того, як сучасні інформаційні засоби навчання можуть покращити когнітивні та мисленнєві функції учнів і налагодити інтерактивний діалог для ефективного сприйняття інформації.

Методологія. У дослідженні використовуються аналітичні методи для вивчення інтеграції мобільних технологій у фізичні лабораторії.

Результати. Досліджено як комплексне застосування технічних засобів у поєднанні з традиційним лабораторним і демонстраційним обладнанням може відкрити нові дидактичні можливості. Ці можливості наразі недостатньо розвинені, але мають значний потенціал для посилення інтерактивної взаємодії в інформаційно-освітньому середовищі. Використання мобільних технологій у лабораторних роботах мотивує студентів і забезпечує більш цікавий та ефективний навчальний процес.

Висновки. У статті визначено як мобільні технології на уроках фізики є ефективною альтернативою традиційним методам. Вони створюють цікаве навчальне середовище, долаючи розрив між теорією та практикою, а також підвищують мотивацію студентів, розвивають критичне мислення та навички розв'язання проблем. Дослідження підкреслює важливість інноваційних методів навчання в сучасній освіті.

Ключові слова: лабораторна робота; фізика; смартфон; мобільні додатки.