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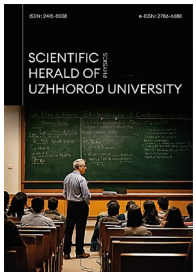

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Formation of students' research skills and abilities with the help of Mobile Learning in the course of general physics

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Abstract

Relevance. The relevance of this research work is to investigate the impact of mobile learning methods on students' academic performance in the course of general physics based on university-level physics laboratories, since similar studies show that allowing students to solve mathematical models of physical processes exclusively on their smartphones rather than on traditional personal computers tends to improve students' academic performance.

Purpose. The purpose of this research work was set, which is to study the impact of mobile learning on the formation of research skills and abilities in the study of general physics course, and in particular in the construction of mathematical models, which include methods of differential and integral calculus.

Methodology. To achieve the goal of this research work empirical methods of research were used, which consist of observation, direct experiment, generalization and analysis of the results obtained. For the research two groups of students were formed – control and experimental, who studied the same physics disciplines, only the control group did it on personal computers, and the experimental group did it on smartphones.

Results\Conclusions. The results of the experiment showed that the use of smartphones in the building of mathematical models in the course of general physics increases the academic performance of students. The results of this research work have prospects for use in the development of new techniques in education, in particular for the course of general physics and other research subjects. The results are also in demand for the analysis of student results obtained in mobile learning, which can be used to improve the academic performance of students.

Keywords: mobile learning; education; higher education; use of smartphones; mathematical modeling; Kazakhstan.

Introduction

Due to the rapid development of technology in the modern world it is necessary to pay great attention to the sphere of education, because today's students need an education that goes in rhythm with the surrounding world, science and the development of technology. Students' perception of information has changed significantly in recent times, which was the trigger for the development of new methods of education. The use of information and communication technology expands the possibilities of the educational process [1]. Also, the field of education has experienced great changes due to the COVID-19 pandemic, as it was necessary to provide a safe learning environment, but at the same time not to reduce the quality and level of knowledge received [2; 3]. In this regard, many distance education methods have been improved and launched, such as E-Learning (electronic learning) and M-Learning (mobile learning) [4].

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M-Learning is a modern and quite effective method of learning, which is the use of mobile technology in the learning process instead of personal computers. The term mobile learning, appeared in pedagogical literature more than fifteen years ago [5-7], but recently this type of education is becoming more and more popular. M-Learning has many advantages, among which it is possible to note: automation of learning process; possibility to study material at any time and in any convenient place; possibility always to repeat necessary material; personalization; development of self-education skills, which will be necessary in future life of students; practicality, because the work needs only a phone, which does not take much space and is always available [8; 9]. It should be noted that M-Learning can be used both for traditional learning and for complete distance learning [4]. Most countries in Europe and the USA use M-Learning for quite a long time and effectively, relative to the CIS (Commonwealth of Independent States) countries these methods of training have only recently begun to be in demand. Kazakhstan, in turn, has been practicing the use of E-Learning and M-Learning methods in education for more than five years [10-12]. In recent years, due to the ongoing educational reforms, Kazakhstan has made significant progress in the education system. At the moment, Kazakhstan is focused on reforming the higher education system to improve competitiveness in the global market. Reforms in the higher education system are designed to bring Kazakhstan to the leading positions in the world, to ensure the future of the Kazakh nation and to develop the human capital of the country [13-15].

In recent years, quite a lot of research has been conducted to study the effectiveness of mobile learning methods [16; 17]. Most of the studies were based on testing student performance using mobile learning methods in comparison with other methods. The works of C.-Y. Liu et al. [18], A. Abdulayeva [19], H. Putranta et al. [20], J.A.S. Alé [21], S. Sakibayev [22] were aimed at studying the application of M-Learning methods in studying physics course, and in particular in mathematical modeling of physical processes. In their study, C.-Y. Liu et al. [18] studied the effectiveness of using mobile devices to solve mathematical models in high school physics labs, therefore, it was found that the use of smartphones improves student performance. S. Sakibayev [22] in his work investigated how college students are affected by solving mathematical models exclusively on smartphones, as the research showed the students' academic performance and interest in the subject increased. The work of A. Abdulayeva [19] was aimed at studying the impact of using smartphones on students' understanding of the physical meaning of the concept of acceleration in conducting experiments, according to the results of the work, students who used smartphones in their experiments, better described the graphical dependencies of mechanical motion. Another study, authored by H. Putranta et al [20], which aimed to study the effect of the intensity of smartphone use in physics on the thinking skills of high school students, thus it was found that the use of smartphones improves these skills in students.

As analysis of the literature has shown, at the moment there have been many studies on the effectiveness of M-Learning in physics courses at school level, which show positive results, but there have been not enough studies at the level of higher education. Also it is necessary to make an aspect on research of efficiency of the solution of mathematical models exclusively on smartphones as mathematical modeling of physical processes plays an important role in studying physics course. Consequently, it can be concluded that this area needs additional research. This research article will study the impact of M-Learning on the formation of research skills and abilities of students in the course of general physics, which is the main purpose of this work. This research article will study the impact of M-Learning on the formation of research skills and abilities of students in the course of general physics, which is the main purpose of this work. The set goal and hypothesis of the work is based on the previously conducted studies of C.-Y. Liu et al. [18], which considered the effectiveness of M-Learning for solving mathematical models from the course of general physics of middle school, in this work will be an experiment based on the university level physical laboratory, and mathematical models will include mostly methods of differential and integral calculus.

The theoretical value of this work consists in the analysis of the impact of M-Learning on the academic performance of students, as well as the acquisition of skills and abilities on the basis of the experiment. Practical significance consists in the application of the results of the study to build new teaching methods using M-Learning and improve the academic performance of students, both in Kazakhstan and in other countries.

Materials and Methods

In the process of this research work, empirical methods were used, which are often used for pedagogical research. Empirical methods are directly aimed at the practical knowledge of the studied participants of the pedagogical process. The core of empirical research consists of observation and research, experiment, as well as summarizing, analyzing and classifying the data obtained as a result of the experiment, as well as further practical application of them. In this study an experiment was conducted on two groups of students, where the studied parameter was the method of solving mathematical models, in order to study the impact of methods of mobile learning on student performance. The experiment is an active empirical method of research and is performed on the basis of the theory on which the goals of the study are based. The experiment for this study was conducted throughout the 2019-2020 and 2020-2021 academic years. The experimental base of the research was Zhetysu University named after I. Zhansugurov.

This study can be divided into three main stages: problem statement, experiment, analysis of the results. Accordingly, in the first stage, a literature analysis was conducted to supply the problem and the purpose of the study. The theoretical background of this study is based on the findings of C.-Y. Liu et al. [18], which show the educational effectiveness of mobile devices when used to solve mathematical models from high school physics labs. Consequently, the goal was to study the impact of using mobile devices to solve mathematical models from general physics course, in particular mathematical models that include methods of differential and integral calculus, but

already at the level of university laboratories. Based on the studied material, the following plan of the experimental study was built, which included conducting an experiment based on two groups of students – control and experimental. Students of both control and experimental groups studied the same physical disciplines, the main difference between the groups, which was the essence of the study, was the way of solving mathematical models.

The control group was 30 IT (information technology) students who studied physics for the entire semester of the 2019-2020 academic year. The control group used traditional personal computers to solve mathematical models. In the academic year 2020-2021, the role of the experimental group was played by 30 IT students who studied physics throughout the semester. The experimental group solved mathematical models directly on their smartphones. In the course of the experiment for each of the studied groups the level of students' knowledge was determined by the ECTS (European Credit Transfer and Accumulation System) scale. At the final stage of the research work, based on the results obtained in the course of it, the final conclusions of the scientific research were formulated, the results obtained were summarized and systematized, which reflect the level of academic achievement for the studied groups of students. In general, the results obtained in the course of this scientific research, as well as the conclusions formulated on their basis, can be used in the future as a basis for creating new educational methods using M-Learning, also to improve already existing programs in order to increase the academic performance of students.

Results

In institutions of higher education, especially of technical plan, among all general subjects, a course of physics takes almost the most important place in training of highly qualified specialists, who possess a large amount of obtained knowledge, skills of scientific thinking, research skills, high level of understanding of general rules of science and technology development, the developed worldview. But besides it, a course of physics, since a high school, is considered as one of the most difficult subject, as it besides introduction of difficult concepts, specific laws, huge and difficult remembered formulas and equations, demands also knowledge of the mathematical system. Therefore, in the majority of higher educational institutions a considerable aspect on studying of physics course by students is made, and also it is a push for conducting a lot of educational researches in this sphere.

The study of physics course is primarily based on the development of research skills of students. Research skills are actively developed at high school age, when the formation of cognitive processes is completed, and for students of higher educational institutions it is important to constantly engage to the utmost and develop these skills. The formation of research skills in the process of students' independent work is important, because in higher education institutions independent work is the basis for the development of professional skills. Research skills require more complex experience, such as the ability to observe, develop and use objects naturally even at a very young age, in addition to the skills of comparative analysis, data collection, data interpretation and the ability to make hypotheses [23; 24]. Consequently, the formation of research skills is an essential part of the learning process. Research work mainly refers to the information and development methods of teaching, so to increase these skills are used modern tools of information technology.

Physics and math are very closely connected with each other, as the solution of many physical problems is based on the understanding of the mathematical apparatus. So in a course of physics the important place is occupied by mathematical modeling which promotes formation of research abilities and skills of students, therefore on it the main aspect of the given research work was made. Mathematical modeling is applied in different areas of science and technology, and also at the moment there is an important part of human evolution. In the course of physics mathematical modeling is the basis for the experiment, the study of various objects and processes. It is considered that mathematical modeling contributes to a better understanding of the world and scientific phenomena. Mathematical modeling is an integral part of physical experiment, it allows to predict possible ways of development and results of experiment, possible difficulties and unplanned moments, that in its turn contributes to efficiency and allows to reduce costs of the experiment. Also the use of methods of mathematical modeling allows to investigate properties of objects and processes, to predict their behavior during the experiment in different conditions, to conduct the necessary number of repetitions of the experiment. Through the use of methods of mathematical modeling students are able to study the complex moments of the experiment in more detail, consider their behavior under different conditions and select the optimal conditions for the conduct of the experiment [25; 26].

Solving mathematical models in physics courses actively engages students' research skills, as they learn to analyze physical processes, to take the right ways to solve their problems based on the models obtained. As it was mentioned earlier, the involvement of research skills in physics course is quite a complex task, as it involves many factors. In this regard, there are certain difficulties in constructing methods of studying general physics course at the university level, as it is necessary to correctly and fully engage all the previously introduced skills. The modern process of studying physics course in higher educational institutions should include both classical traditional methods, which consist of lectures, seminars, laboratory and practical classes, solution of various physical tasks, and also modern computer methods. One of the problems faced by some higher education institutions in the transition to distance learning, due to the COVID-19 pandemic, was the task to fully engage and develop students' research skills [20; 27]. These skills are formed directly in the study of theoretical statements and their subsequent application in practice, when performing an experiment, studying various physical processes and phenomena. Thus, in distance learning there are problems definitely with the practical part, as students need to be given the opportunity to perform various physical experiments independently, away from the laboratories. The use of computer technology makes it possible to cope with this task. The use of computer technology in educational courses makes it possible to implement the

model of person-centered learning. Since to solve most of the tasks set for students in physics courses it is necessary to use various gadgets, often personal computers, which are not always promising enough and convenient to use, so an excellent alternative can be the use of mobile devices, which are the basis of M-Learning methods [28; 29].

Applying M-Learning methods to physics courses, including solving mathematical models that include differential and integral calculus methods, has many advantages. Compared to a personal computer, a smartphone is more practical and easy to use. The use of smartphones also improves students' academic performance and learning efficiency, which has been confirmed by previous studies. The use of smartphones in the educational process contributes to an individual approach to each student, the ability to identify the weak and strong sides of students and accordingly select appropriate techniques and make a detailed focus on difficult moments. In mathematical modeling the use of smartphones promotes high concentration of students, simplifies the standard methodology of building models and gives more opportunities for their study. One of the important advantages of using mobile learning is the economic justification, as buying a personal computer is quite expensive compared to buying a mobile device. Smartphones have long been an inseparable part of everyone's life, so buying a smartphone is a higher priority than buying a computer. Also computer classes take up a lot of space and are quite consuming, this is another problem with which the use of mobile devices copes. M-Learning is a great alternative to standard training using PCs, the more so at the moment there are more and more mobile applications for training, which are quite simple to develop. Therefore, research in this area has many prospects.

As mentioned earlier, the premise of this study was the findings of C.-Y. Liu et al. [18], accordingly, the use of mobile devices to solve mathematical models from middle school physics labs improves student performance. The findings of C.-Y. Liu et al. showed that the overall success rate of students in model building was close to 50% while the duration of participants' modeling decreased with the increase in experimental labs. The benefits of performing physics labs using a smartphone were confirmed by success rates, personal preferences, and feedback from students that participated in the experiment. The results showed that the combination of modern data collection and data matching tools with a modeling tool would provide an alternative and meaningful approach to doing physics labs in middle school. As claimed by C.-Y. Liu et al., physics labs in secondary education face two major challenges: following lab instructions step by step to keep students focused on fitting experimental data; and another challenge is that most data recording methods are slow, which reduces the number of samples that can be taken and their accuracy. But these difficulties are not exclusively confined to the Middle School, they are also characteristic at the university level. Therefore, it was set as a goal to study the impact of M-Learning on the level of performance of students in the building of mathematical models in the course of general physics, which include methods of differential and integral calculus, exclusively on smartphones on the basis of university level physics laboratories.

Two groups of students of Zhetysu University named after I. Zhansugurov – a control and an experimental group – were involved in the research. Each group included 30 IT students, who studied the same physical disciplines. The main task of each group was mathematical modeling of physical processes, respectively, for the purity of the experiment the level of complexity of mathematical models was the same for both groups. The investigated parameter in this work was exactly the tool for solving mathematical models. The control group used traditional personal computers to solve mathematical models, while the experimental group solved mathematical models directly on their smartphones. The study took place over two academic semesters: the 2019-2020 academic year for the control group and the 2020-2021 academic year for the experimental group. At the end of the course, students in each group were independently assessed to determine their level of academic success. The results obtained were posted on the ECTS grading scale for each of the groups as a ratio of the proportion of students on a particular grade. The data on the academic performance of each group obtained as a result of the study are summarized in Table 1; 2. Table 1 shows the results for the control group, and Table 2 shows the results for the experimental group, respectively.

Table 1. Assessments of students in the control group

Grade	Relative Frequency
A	0.07
B	0.43
C	0.49
D	0.01
E	0.00

Table 2. Assessments of students in the experimental group

Grade	Relative Frequency
A	0.12
B	0.62
C	0.26
D	0.00
E	0.00

On the basis of Table 1; 2 in the Excel spreadsheet environment, a diagram of the distribution of the proportion of students depending on the grade (Figure 1). Green columns on the diagram correspond to the results of the students of the control group, and blue columns correspond to the results of the students of the experimental group.

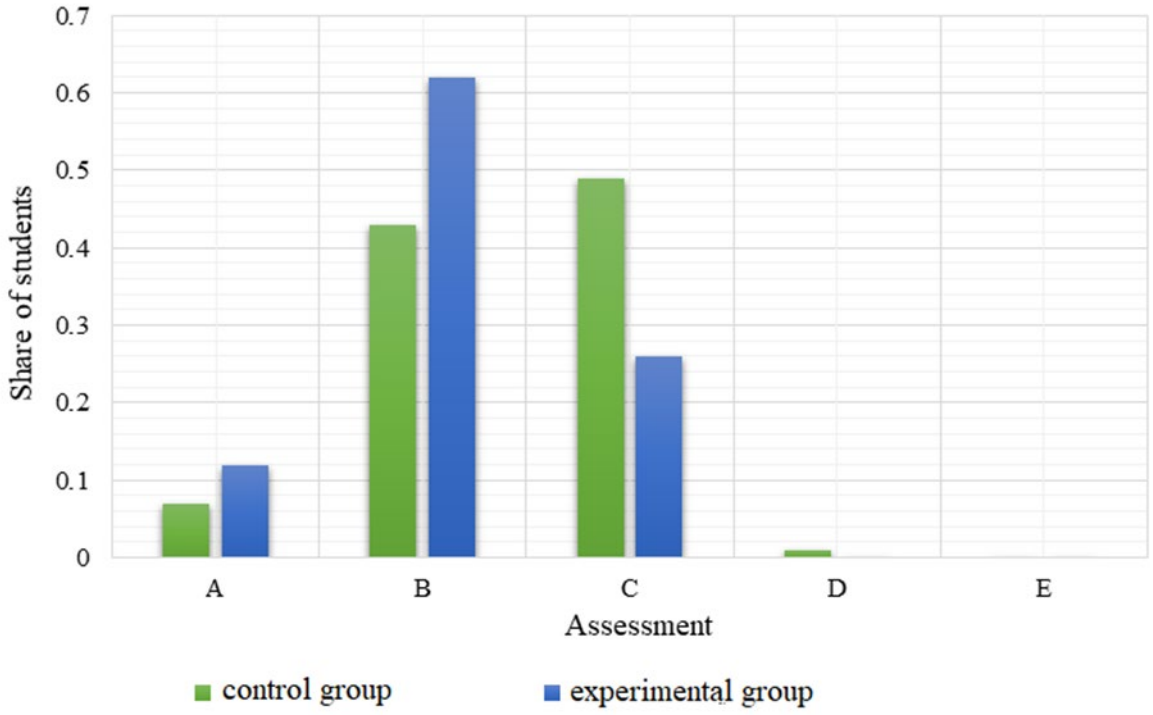

Figure 1. Diagram of the distribution of the proportion of students on the assessment scale for the control and experimental group

As the diagram shown on Figure 1, for the experimental group, which used smartphones to solve mathematical models, there are higher rates of assessments of the level of knowledge. So for the group of students who used M-Learning methods, the share of C-level assessments decreased from 0.49 to 0.26, that is, by 50%, also there are absolutely no D-level assessments. But at the same time, the share of A-level assessments increased by 40%, from 0.43 to 0.62, and the share of B-level assessments increased by 30%, from 0.07 to 0.12, as compared to the group of students who used personal computers to solve mathematical models in the general physics course. Therefore, the results obtained, it can be concluded that the use of mobile devices in the process of modeling mathematical models in the course of general physics contributes to improving the performance of students. This is due to the effective, simpler and more convenient implementation of mathematical modeling methods on smartphones. When using smartphones, students better engage their thinking, attention and concentration because it is easier to focus on important details of mathematical models on a smartphone screen compared to personal computers, which partially dissipate students' attention. Also, the use of smartphones increases interest in the learning process, as the learning environment changes from standard work using personal computers to new more interesting and practical methods of mobile learning.

Discussion

With the rapid development of information technology, smartphones have taken a major place in everyone's life. More and more people are using mobile devices not only as a means of communication and entertainment, but also for the purpose of gaining new knowledge. Many educational courses are adapted specifically for learning through smartphones. So it is not surprising that smartphones are increasingly replacing personal computers [30; 31]. This research work was aimed to map and explore the features and impact of mobile devices and their application in the formation of students' research skills and abilities in the course of general physics in the context of higher education. The main aspect of this research was to solve mathematical models in the course of general physics using smartphones instead of personal computers, because mathematical modeling is an essential part of the physical process, as well as a crucial skill for improving the level of students' research skills. The main purpose of applying mathematical modeling in teaching physics to higher education students is to develop students' ability to mathematically model technological processes when solving physics problems with professional content. Often universities use personal computers to solve mathematical models, but this is not always an effective and practical method, so it was investigated how the academic performance of students will be affected by the use of smartphones to solve mathematical models by students [32-34].

As a result of the experiment it was determined that the level of academic achievement of students increases with the use of M-Learning methods for solving mathematical models, which include methods of differential and integral calculus. Based on the results obtained during the experiment, the proportion of A-level and B-level grades of students increased by 40 and 30%, respectively, which

is quite high. In order to compare the results obtained, as well as to confirm or refute the hypotheses, research in this area by other authors in recent years of publications was studied. As the analysis of the literature in recent years has shown a lot of research on the effectiveness of mobile learning methods, both in school education and at the level of higher education. Most of the studies have shown positive results, that is, for the experimental groups there has been an increase in the level of academic performance of students. In an article by S. Sakibayev [22] described an experiment in which college students solved mathematical models on smartphones in an extracurricular math club. In the course of the article the author describes the mathematical models posed to the students, analyzes their performance and collects their personal opinions about the quality of learning and their preferences. According to the results of the experiment, it was concluded that the use of smartphones in mathematical modeling classes has a positive impact on students' performance and interest in the subject, also there were more positive grades among students who used smartphones than among students who used personal computers.

Another study in this area has shown positive results. So A.R. Aththibby et al. [35] conducted an experiment for three groups of 90 students from two universities in Lampung Province, Indonesia. This study was conducted during the COVID-19 pandemic and aimed to develop students' motivation and scientific process skills. As the results of the experiment showed that mobile laboratory learning is quite effective in developing students' motivation as well as scientific process skills. The groups of students who participated in the experiment showed an increase in academic performance and interest in learning physics using smartphones. The article by A. Abdulayeva [19] presents the results of the study of the impact of experiments with smartphones on students' understanding of the physical meaning of the concept of acceleration. The research, as well as this work, took place on the basis of Zhetysu University named after I. Zhansugurov. The results showed that before the experiment, there was no significant difference in the understanding of this material by the students of the experimental and control groups. But during the experiment, it was shown that the use of smartphones allows students to describe motion using position-time graphs, to describe motion using acceleration-time graphs, and to describe motion using diagrams. The results show weak statistical differences between the two groups. However, students who used a smartphone in their experiments were better at describing graphical dependencies of mechanical motion.

A study by H. Putranta, et al. [20] aimed to study the effect of intensity of smartphone use in physics learning on the higher-order thinking skills of high school students. The results of this research work showed that the intensity of smartphone use and the level of students' higher-order thinking skills in physics learning are in the high and low categories with percentages of 48.72% and 51.28%, respectively. As stated in the work, higher-order thinking skills are influenced by the intensity of smartphone use in physics learning by 21.10%. The results showed that the intensity of smartphone use in most students is very high, but cannot yet optimally contribute to higher-order thinking skills. Therefore, a correct methodology for smartphone use in physics learning is needed so that students can optimize their higher-order thinking skills. The above research confirms the hypotheses put forward earlier in this research work that the use of mobile devices instead of personal computers contributes to the improvement of academic performance of students. And also the analysis of the literature and the results obtained in the course of the study are the basis for the application of M-Learning techniques in the educational plan. According to the research work, it can be concluded that M-Learning has many prospects not only for educational methods of middle school, but also in the context of higher education. It is also possible to note that M-Learning is promising as an alternative to computers in traditional teaching, as well as for complete distance learning.

In turn, smartphones can replace personal computers in education, which will be more practical, for example, in the transition to distance learning, students will work in an already adapted learning environment. From the problems that may face universities in the transition to methods of M-Learning, may be the fact that smartphones will need to be periodically charged, as active use will lead to high power consumption, also inherent limitations in memory smartphones, as a personal computer can provide more memory than a smartphone, but to solve this problem is possible to use cloud storage and create training programs with small memory requirements. Another problem that can be highlighted is the small screen of smartphones, but it is worth noting that often when working at a computer not all the screen space is used to convey information, while smartphone screens can provide more focus on important aspects of learning, including the construction of mathematical models. In general, using smartphones instead of personal computers has high priorities. The results obtained during the research can be used to create and improve educational methods at the university level in order to improve the academic performance of students. Among other things, the results of the work can be used for further research in the field of pedagogy or improving the qualifications of teachers. Also, in connection with the educational reforms in Kazakhstan, the data obtained during the study may be useful for improving the competitiveness and entry into the global market of educational platforms in Kazakhstan.

Conclusions

In the course of this research work the impact on the academic performance of students was studied using mobile gadgets when solving mathematical models in the course of general physics, which include methods of differential and integral calculus, on the basis of the university level physical laboratory. The research was conducted throughout the 2019-2020 and 2020-2021 academic years for two groups of students at Zhetysu University named after I. Zhansugurov, which included 30 IT students each studying physics throughout the semester. Each of the groups studied the same physics subjects, only the first conducted calculations on personal computers, and the second exclusively on smartphones. Therefore, the results obtained during the experiment found that the group of students who used smartphones to solve mathematical models had higher scores than the group of students who used personal computers for calculations. Thus, it was

obtained that with the use of M-Learning methods for solving mathematical models the share of A-level students' scores increased by 40% and B-level students' scores increased by 30%.

In the course of the work all the goals set before the experiment were achieved and the hypotheses were confirmed. Accordingly, it can be concluded that the use of smartphones in the learning process contributes to improving the academic performance of students. The results obtained, can be the basis for the creation of educational methods, which include M-Learning, where the smartphone will be used as the main environment for calculations in the laboratories, instead of personal computers, or as a distance learning method to improve the academic performance of students in Kazakhstan. The goal of further research may be to conduct experiments based on other universities to expand the sample and confirm the results obtained, as well as to conduct experiments using mobile devices to solve more complex mathematical models not only from physics course, but also from other research subjects.

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Conflict of Interest
None.

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Формування дослідницьких умінь і навичок студентів засобами мобільного навчання в курсі загальної фізики

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Анотація

Актуальність. Актуальність даної наукової роботи полягає в дослідженні впливу мобільних методів навчання на успішність студентів з курсу загальної фізики на базі фізичних лабораторій університетського рівня, оскільки подібні дослідження показують, що надання студентам можливості розв'язувати математичні моделі фізичних процесів виключно на своїх смартфонах, а не на традиційних персональних комп'ютерах, має тенденцію до покращення успішності студентів.

Мета. Було поставлено мету даної наукової роботи, яка полягає у дослідженні впливу мобільного навчання на формування дослідницьких навичок та вмінь при вивченні курсу загальної фізики, і зокрема при побудові математичних моделей, які включають методи диференціального та інтегрального числення.

Методологія. Для досягнення мети даної наукової роботи були використані емпіричні методи дослідження, які складаються зі спостереження, безпосереднього експерименту, узагальнення та аналізу отриманих результатів. Для проведення дослідження було сформовано дві групи студентів - контрольну та експериментальну, які вивчали однакові фізичні дисципліни, тільки контрольна група робила це на персональних комп'ютерах, а експериментальна - на смартфонах.

Результати\Висновки. Результати експерименту показали, що використання смартфонів при побудові математичних моделей в курсі загальної фізики підвищує академічну успішність студентів. Результати даної науково-дослідної роботи мають перспективи для використання при розробці нових методик в освіті, зокрема для курсу загальної фізики та інших навчальних дисциплін. Результати також є затребуваними для аналізу результатів студентів, отриманих у мобільному навчанні, що може бути використано для покращення академічної успішності студентів.

Ключові слова: мобільне навчання; освіта; вища освіта; використання смартфонів; математичне моделювання; Казахстан.