Experience in the Use of Mobile Technologies as a Physics Learning Method

Tetiana Goncharenko [1[0000-0002-2021-9320]], Nataliia Yermakova-Cherchenko [1[0000-0001-9438-4866]], Yelyzaveta Anedchenko [1[0000-0002-9783-9130]]

[1]Kherson State University 27, Universitetska st., Kherson, 73000 Ukraine
goncharenkokspu@gmail.com, grafinjamonsoro@ukr.net,
liza.anedchenko@ukr.net

Abstract. Swift changes in society, related to sciences technicians' development, technologies, by the increase of general volume of information, pull out new requirements for maintenance, structure, and quality of education. It requires teachers to diversify a tool in the direction of the increase in possibilities of the use of mobile technologies and computer systems. Lately in the world, more attention spared to the use of mobile learning, which in obedience to «Recommendations of UNESCO on the questions of a policy in the area of mobile learning» foresees the use of mobile technology, both separate and together with other by informational computer technologies. [1]. Mobile learning allows using the open informational systems, global educational networks, unique digital resources which belong to different educational establishments and co-operate with each other. The use of existent educational resources and creation of own, based on the academic resources from informative space, allows to promote the interest of students to the study of physics, to take into account the individual features, and also features of region and framework of society of the country.

During the last years in Ukraine competency-based approach to the organization of studies certainly one of basic. The new Education Act addresses the key competencies that every modern person needs for a successful life, including mathematical competence; competence in natural sciences, engineering, and technology; innovation; information and communication competence [2]. This further emphasizes the importance of providing students with quality physical education and the problems associated with it. Using mobile technology in professional teaching work, the teacher has the opportunity to implement the basic principles of the competence approach in teaching physics. An analysis of the data provided in the official reports of the Ukrainian Center for Educational Quality Assessment showed that the number of students making an external independent assessment in physics and choosing a future profession related to physics has decreased significantly. This is due to the loss of students' interest in physics and the complexity of the content of the subject, as well as the increase in the amount of information that students need to absorb. In this article, we explore the possibilities of mobile technology as a means of teaching physics students and give our own experience of using mobile technology in the process of teaching physics (for example, the optics section in primary school).

Keywords: mobile learning, mobile applications, mobile technologies, informational computer technologies (ICT), physics, learning method, curriculum.

1 Introduction

Worldwide, education is a major global priority, a major driving force behind the empowerment of people [3].

Education is the basis of personal development, its successful socialization, economic well-being, the key to the development of society and the country [2]. Therefore, in Ukraine, as in the world, great attention is paid today to expand access to quality, competitive education, following the needs of society, individual characteristics, abilities, and needs of education recipients, the possibility of continuing education throughout life [4].

Understanding that the use of mobile technologies enhances access to quality education, especially in subjects of technical and natural sciences, leads to the fact that their use is gaining popularity around the world. According to UNESCO, mobile technologies can significantly expand learning opportunities in any environment. Indeed, today, mobile devices (mobile phones, tablets) are used everywhere by students and teachers to obtain information, organize, refine different forms and stages of the learning process, manage the learning process, and use innovative methods. [1].

The use of mobile technologies in the context of quarantine in most countries in connection with the threat of COVID-19 coronavirus is of particular relevance, which makes it necessary to organize distance learning of educational recipients at all educational levels. The article aims to present the experience in implementation of mobile technologies (in particular, mobile applications, platforms, and resources) as a means of teaching physics students (based on the analysis of mobile applications, platforms, and resources, educational and methodological support for the education of optics students in primary school was developed).

2 Related Works

The analysis of the literature and Internet resources allowed us to find that:

1) mobile technologies - learning technologies based on the use of mobile devices, mobile applications and services, as well as mobile communications in the learning process [5], today is one of the areas of information technology (ICT), rapidly developing and can be used both individually and in combination with other pedagogical technologies to achieve a common educational goal;

2) mobile technology - as a learning tool, includes a wide variety of digital and portable mobile devices (smartphones, tablets, etc.) and related software (mobile applications and services) that enable operations to receive, process and disseminate information [6];

3) Many aspects of the use of mobile technologies have been devoted via work of many native and foreign scientists, in particular:

- The psychological features of the use of mobile technologies are devoted to the work of such scientists as P. Kirschner & J. Jeroen van Merriënboer [7];
- the current state and possibilities of using mobile learning and mobile educational environment – J. Traxler [8], V. Bykov [9], M. Ky`slova, S. Semerikov, K. Slovak [10], Y. Trius, V. Franchuk, N. Franchuk [11];
- the use of mobile technology as a means of teaching physics – T.Compernolle [12], O. Lyashenko, S. Tereshchuk [13];
- mobile, information technology and learning tools from a systemic approach – M. Stryuk, S. Semerikov, A. Stryuk [14];
- use of various mobile applications and services in the educational process – S. Carretero, R. Vuorikari, Y. Punie [15], J. Krause, K. O'Neil & B. Dauenhauer. Plickers [16], I. Korobova, T. Goncharenko, N. Golovko, O. Hniedkova [17], however, the methodological development of lessons using mobile technologies is insufficiently covered;

4) UNESCO identifies the unique benefits of mobile learning, including empowerment and equal access to education; personalization of training; instant feedback and evaluation of learning outcomes; learning anytime, anywhere; effective use of class time; formation of new student communities; support for situational training; development of continuous "seamless" training; providing a link between formal and non-formal learning; minimization of the consequences of the destruction of the educational process in military zones; conflicts or natural disasters; assistance to students with disabilities; improving the quality of communication and management; maximizing cost-effectiveness [1];

5) mobile learning is considered [9, 10, 14] as a separate area in the use of ICT in education, with scientists identifying several advantages of using mobile technology over traditional ICT, in particular: accessibility of mobile devices and mobile applications and services; the opportunity to study anywhere, anytime; compactness of mobile devices; development of related technologies related to the transmission and storage of information on the Internet (cloud technologies); continuity of access to training materials; increased interactive learning; ease of use; personalized learning [11, 18, 19];

6) at the same time, the question of the use of mobile phones in the educational process is debatable today. In many countries, restrictions are imposed on their use at school: 1) in 2018, France adopted a law prohibiting the use of mobile phones in primary and secondary schools [20]; 2) in some schools in the US and Europe use the so-called a Yondr Pouch, a small bag with a magnetic lock that holds a cellphone in the class [21]; 3) in Victoria (Australia), as of 1 semester 2020, mobile phones in all public schools must be excluded and stored throughout the day, except for educational purposes [22]; 4) The UK has announced in 2019 its intention to ban mobile phones in schools, with exceptions to the ban when students use phones to monitor their health or to provide a lesson to students using mobile phones. [23]. Thus, in most countries, there are some restrictions on the use of mobile phones by

schoolchildren, but educational institutions are allowed to use mobile technologies for educational purposes within the framework of M-learning;

7) The main uses of mobile technology in the educational process are the use of mobile applications, platforms, resources, and mobile sensors. The subject of the study of this work has been selected for mobile applications.

Highly appreciating the research and the achievements of scientists on this problem, it is necessary to point out the need to continue scientific research in this area, in particular the study of the possibilities of using mobile technologies as a means of training students of physics and the development of appropriate educational and methodological support.

The analysis of existing mobile applications, platforms and resources has led to the conclusion: there are a large number of applications freely available (Google Forms, Survey Monkey, Kahoot!, Socrative, Plickers and many more), they can work in different operating systems (Windows, Linux, Android) and can be used by both students and teachers during lessons as well as self-study at home. Features of using different mobile applications and services are listed in Table 1.

Table 1. Features of use of various mobile applications and services

<table>
<tr><th>№</th><th>Name of mobile app, service, and more</th><th>Content and activity orientation</th><th>Time to use in the learning process</th></tr>
<tr><td>1</td><td>Google Forms</td><td>allows you to create large-scale surveys with questions of different types; provide students with answers from their own mobile devices</td><td>while working in the classroom,
and remotely (polls for a long time)</td></tr>
<tr><td>2</td><td>Google Classroom</td><td>allows you to create, distribute and classify tasks; track the progress of each student, adjust feedback by commenting on student performance</td><td>while working in the classroom,
and remotely (use for a long time)</td></tr>
<tr><td>3</td><td>Kahoot!</td><td rowspan="3">rapid processing of test or survey results</td><td rowspan="3">when working with a classroom audience</td></tr>
<tr><td>4</td><td>Socrative</td></tr>
<tr><td>5</td><td>Plickers</td></tr>
<tr><td>6</td><td>web browser Chromium</td><td>storing and using information regardless of the equipment used to access cloud resources;
Allows cloud technology</td><td>independent choice of tasks and time for their execution;
lets you work on your mobile phone</td></tr>
</table>

7	cloud environment Dropbox	to synchronize the work of received data across devices	(smartphone) from where it was suspended on your computer and vice versa
8	Moodle	information environment for distance education	while working in the classroom, and remotely
9	Get a class: Smart	includes materials in physics: videos, theoretical materials, physical problems, virtual labs, virtual experiments, preparation for final exams	while working in the classroom, and remotely, independently
10	Physics virtual lab		
11	Science experiments in physics lab		
12	Physics at school		

These resources offer a wide range of educational services from studying theoretical material, watching video lectures, performing practical tasks (solving problems, performing a virtual experiment, etc.) to creating and passing tests and various control tasks aimed at helping students and teachers in physics training. When using these applications, the teacher can perform supervising, teaching, orienting, educational functions. These additions help to increase the cognitive interest of students and the quality of their teaching, and also allow the teacher to organize the preparation of students in physics and evaluation of their activities: 1) the level of knowledge of theoretical knowledge that can be revealed during oral or written questioning, testing; 2) the level of ability to use theoretical material in solving physics problems of different types; 3) level of practical skills that can be found during laboratory work and physics workshop; 4) content and quality of students' creative work.

3 The Presentation of Main Results

There are: plot, informational and methodical parts in the structure of training case. The analysis of the considerable amount of resources that can be used in mobile technologies has led to the need for questioning of physics teachers and students to study their experience of using mobile technologies. The results of the questionnaire made it possible to identify a list of mobile tools and applications that could be used in physics lessons by teachers and students without additional training in their use, or by providing methodological recommendations. Pupils of 9-10 grades of general secondary education institutions, totaling 82 persons, were involved in the questioning. In Fig. 1 shows the distribution of students by choice of applications that they use most often on their mobile devices: 1 - browser (Google, Opera, etc.) - 85%; 2 - "mail client" - 77%; 3 - «instant messaging client» (Viber, Telegram, WhatsApp) - 85%; 4 - applications for communication on social networks (Instagram, Facebook, Twitter, etc.) -78%; 5 - educational applications (Castle Quiz, Duolingo, MalMath) - 20%; 6 - e-book reader applications (CoolReader, FBReader, Play Books) - 15%; 7 - office applications (Word, Excel, etc.) - 10%; 8 - dictionaries and translators - 44%; 9 - mobile games -92%.

The results of the survey indicated that students most often use mobile devices for gaming applications; various browsers, instant messaging clients, social media applications; the least students use e-books, training applications, and office applications (Fig.1).

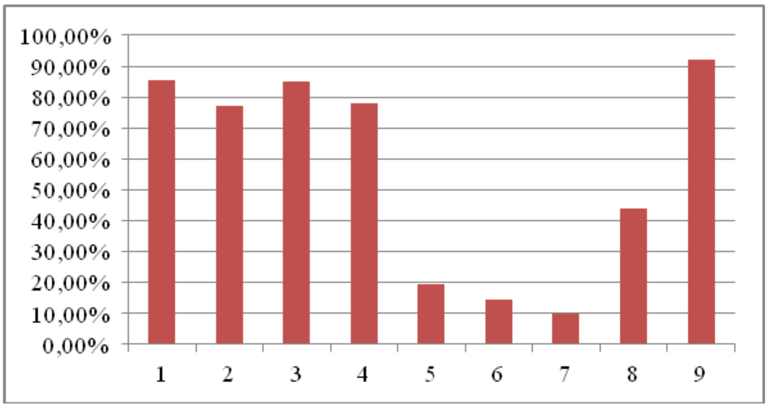


Fig.1. Categorization of students by mobile app usage level

When asked about the convenience of ways of perceiving new material, the students' answers were distributed as follows: 10% prefer reading the text of the textbook; 16% better perceive information through pictures and diagrams in the textbook; 22% - use audio and video snippets to improve the perception of new educational material; 52% expressed a desire to learn new material in the form of a game.

To the last question of the questionnaire regarding the modernization of the process of studying physics through the use of mobile applications, 94% of the observed respondents gave a positive answer.

Summarizing the results of the questionnaire survey of students, it can be argued that students are actively using mobile tools and applications in everyday life, but not for the learning process.

A survey was also conducted among physics teachers in Kherson (17 people).

The survey results indicated that only 23% of the teachers could define the concept of "mobile technology"; 71% know and use mobile technologies, but cannot give a clear definition; 6% did not encounter mobile technologies (Fig.2).

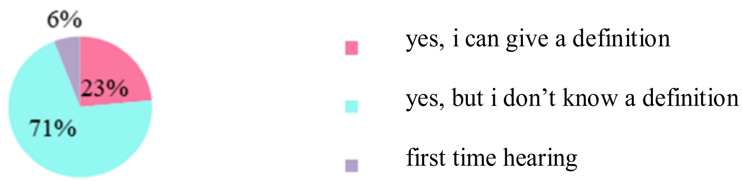


Fig.2. Distribution of teachers' answers to question 1

The second questionnaire revealed the level of awareness of teachers with mobile applications adapted to the study of physics in Ukrainian schools and their use in the educational process. 12% of teachers surveyed know and use mobile applications in their professional activities; 41% of respondents know, but do not use mobile applications in the educational process; 47% do not know about mobile applications (Fig. 3).

Fig.3. Distribution of teachers' answers to question 2

When asked about the possibility of using a ready-made mobile application in their professional activity, 76% of the interviewed teachers expressed a desire to introduce innovations in the educational process, 18% - hesitated about the introduction of mobile technologies, and 6% did not see this need (Fig. 4).

Fig.4. Distribution of teacher responses to question 3

To the question of whether the use of mobile technologies in the process of teaching physics in the development of students' interest in the study of physics and enhancing their educational achievement, 94% of teachers gave a positive answer (Fig. 5).

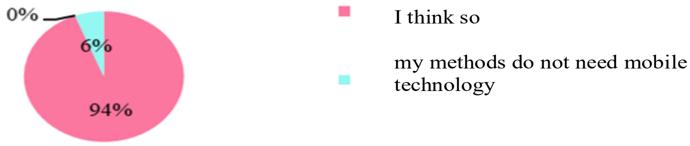


Fig.5. Distribution of teacher responses to question 4

Summarizing the results of the survey of teachers, we can say that they are ready to introduce innovative teaching methods in the educational process, in particular the use of mobile technologies in teaching physics. The results obtained once again confirmed the relevance of the chosen research topic and prompted the development of methodological recommendations for the use of mobile technologies in physics lessons in primary school. The analysis of mobile applications and literary sources on the application of mobile technologies in Physics learning allowed developing planning for the use of mobile technologies as a means of teaching physics students in studying the phenomena of light in grade 9 (Table 2). At the same time, among the many analyzed mobile applications, programs, games, and sites, we have chosen to use five of them to study light phenomena: Get a class: Smart; Physics virtual lab; Science experiments in physics lab; Physics at school; Plickers (Table 2).

Table 2. Planning the use of mobile technologies as a means of teaching physics students while studying the section "Light phenomena" in grade 9

№	**Theme**	**Recommended mobile app**
1	Light phenomena. Speed of light propagation	Physics at school
2	Light beam. The law of rectilinear propagation of light. Solar and lunar eclipse	Get a class: Smart
3	The law of rectilinear propagation of light. Task Solving	Physics at school,
4	Reflection of light. The law of reflection of light. Flat mirror	Physics at school, Science experiments in physics lab
5	Solving light reflection problems	Get a class: Smart
6	**Laboratory Work № 3:** Studying the Laws of Reflection of Light Using a Flat Mirror	Science experiments in physics lab
7	Refraction of light at the boundary of two media	Physics virtual lab
8	Solving Refraction Problems	Get a class: Smart
9	**Laboratory Work № 4:** Light Refraction Research	Physics at school
10	Decomposition of white light into colors. Color formation	Get a class: Smart
11	Lenses. Optical power and focal length of the lens	Physics at school
12	Capture images with a thin lens. The formula of a thin lens. The simplest optical devices	Physics virtual lab
13	Lenses. Tasks solving	Physics at school
14	**Laboratory work № 5:** Determination of focal length and optical power of a thin lens	Get a class: Smart
15	Lenses. Tasks solving	Physics at school
16	The eye is like an optical device. Vision. Vision	Physics at school

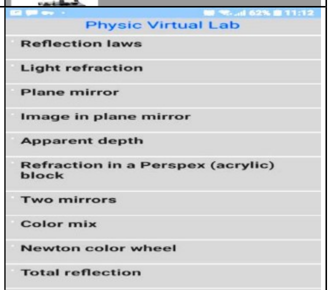
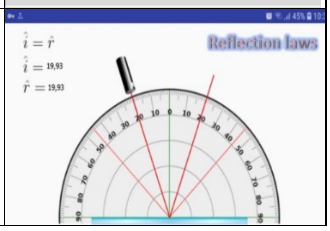
	defects and their correction. Glasses	
17	Light phenomena. Tasks solving	Get a class: Smart
18	**Test № 2 Light phenomena**	Get a class: Smart
19	**Protection of educational projects**	Each or any of them

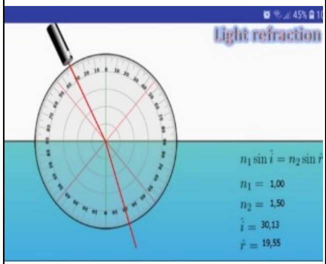
In the course of the research, a set of tasks (with step-by-step instructions for their use) was developed, aimed at the use of such mobile applications, programs, games, sites as Physics virtual lab; Science experiments in physics lab; Physics at school; Plickers; Get a class: Smart during the study of the "Light phenomena" students are aimed at developing their cognitive interest in the study of physics, and improving the quality of their learning.

The effectiveness of using the selected mobile applications is based on their features, namely:

- ***Physics virtual lab*** [24] - The mobile application (English version) is a virtual physics lab that allows you to test basic laws in physics using touch control. Step-by-step use of the Physics virtual lab site to study the laws of reflection and refraction is shown in Table 3.

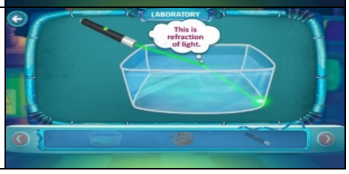
Table 3. Physics virtual lab as a tool for learning the laws of reflection and refraction of light

№	**Step-by-step actions**	**The image on the screen**
1	The menu view of the mobile application	
2	The laws of reflection and refraction of light. Choose a category: «Reflection laws»	
3	Demonstration of the law of reflection: change the angle of incidence of the beam - the angle of reflection changes automatically. Conclusion: The angle of incidence is equal to the angle of reflection.	

4	Demonstration of the law of refraction of light: the beam refracts at the boundary of the air and water; the refraction angle is less than the incidence angle; changing the angle of incidence of the beam causes a change in the angle of refraction. Conclusion: The ratio of the sine of the angle of incidence to the sine of the refraction angle for the two media is unchanged and is equal to the relative refractive index.	

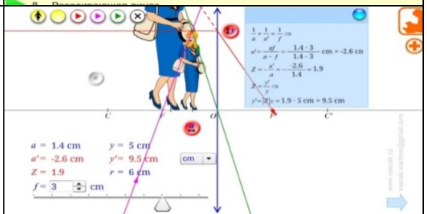
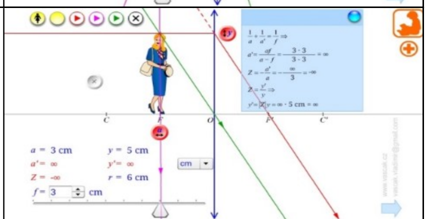
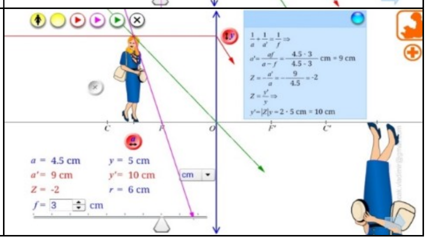
- ***Science Experiments in Physics Lab*** [25], a mobile application (English version), is a virtual physics lab that lets you test basic laws of physics in the form of a scientific game using touch control. In our opinion, it is one of the most successful scientific games that are suitable for all ages. Unlike the previous mobile application, there is a character in this game that acts as a guide and speaks rather slow and understandable English throughout the game. Using this app, you can achieve two goals: 1) learning to perform virtual experiments in physics; 2) to learn physics in English, to develop skill in communication in a foreign language. After the virtual experiment is followed by an audio and visual explanation. Audio explanation allows you to check the readability of the written text, to find and learn unfamiliar words. The only downside to this program is the small number of physical experiments (7 in total). But we hope that it will be improved and supplemented over time. An example of using the application as a teaching tool for physics students with a step-by-step explanation is shown in Table 4.

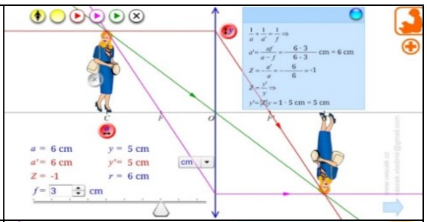
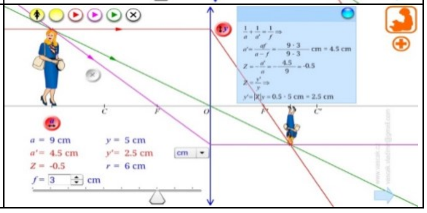
Table 4. Science experiments in the physics lab as a means of studying the theme "Refraction of light in different environments" (fragment)

№	Step-by-step actions	The image on the screen
1	We choose the theme "Refraction of light in different environments".	
2	We are offered to make an experimental setup and select materials for the experiment. It allows you to perceive the name of objects by ear while seeing the image and name of the object on the screen.	
3	With the above program, we make the necessary installation, the appearance of which we see on the screen. We choose the angle of incidence.	

- *Physics at school* [26] is a mobile application, free of charge and available for download on Google Play. The program is available in various languages (wide list). After choosing a language, 16 sections of physics themes are opened. This mobile application is no longer a game. It has the appropriate rules of use, provides that the student has some theoretical background. However, it is convenient to use this program when studying the relevant topic, both in the lesson and when doing homework. One of the main advantages of this app is the presence of mini-experiments with calculations for any topic in the school physics course; you can change the parameters of the experiment independently; vivid animations (Table 5).

Table 5. An example of using Physics at school mobile application while learning about Lenses. "Optical power and focal length of the lens", "Capture images with a thin lens. The thin lens formula"

№	Step-by-step actions	The image on the screen
1	Choose a topic: "Collecting lens"	
2	The subject is in focus. We perform construction (focal length can be changed, as well as the size of the object, and its appearance). We get an enlarged, direct, and imaginary image of the subject.	
3	The subject is in the focus of the collecting lens. From the 9th-grade physics course, we know that the subject in focus will not have an image in the collecting lens.	
4	The subject is between the focus and the dual focus of the collecting lens. We get an enlarged, inverted, true image of the object.	

5	The subject is in the second focus of the collecting lens. Get an inverted, valid, evenly sized object.	
6	The subject is behind the second focus of the collecting lens. We obtain a true, reduced and inverted image of the object.	

- Plickers [27] - the program consists of several applications that only work in complex form. Provides teachers work with the classroom, allows you to quickly, effectively, and visually conduct a front-line survey. Algorithm and methodological features of mobile application usage Plickers:

- register on the official Plickers.com site;
- create a class that we intend to work with and enter the names of students with numbers;
- ask four-choice questions or true-false questions. The free demo can only ask you five questions, but with multiple sets of questions, you can run them at one time;
- to identify each student, they are provided with cards with a QR code, through which students can answer questions;
- in order to provide the correct answer to the question posed by the teacher, students need to return the card with the code so that the correct answer (a, b, c, d) is on top;
- the teacher checks the Plickers mobile application by scanning the students' nameplates. On the screen of his or her phone, the teacher receives statistics of correct answers, which are given as a percentage of each question.

- Get a class: Smart [28] - The web site is freely available to students, teachers, and can be used on a mobile device and computer. Provides many opportunities for the study of physics 7-11 grades, has a section on preparation for the final exam. Each of the topics is selected at least 20 tasks that are solved interestingly. A character named Smart acts as an assistant throughout the training process. On the site, students can independently work the material, test, and evaluate their knowledge; the teacher can set up assignments for test work, conduct online testing during physics classes, which students can see immediately.

Through these applications, the teacher can evaluate the quality of the students' knowledge and correctly set the focus for future lessons.

Taking into account the advantages of using different mobile applications, we developed a teaching and methodological support for the study of the section "Light phenomena" in grade 9, which included lesson notes (with a description of teacher and student activities) and lessons (virtual experiments, tests, etc.) with tutorials and step-by-step instructions for teachers and students on mobile applications.

The effectiveness of the developed methodological recommendations aimed at the use of mobile technologies as a means of teaching physics students was tested by introducing it into the educational process of the OV Mishukov Kherson Academic Lyceum at the Kherson State University. The total number of students involved in the pedagogical experiment is 30.

The criterion for the effectiveness of the developed methodological recommendations for the use of mobile technologies in the educational process was chosen the level of educational achievements of 9th-grade students in physics, characterized as follows:

Beginning level: the student's response when playing the educational material is elementary, fragmentary, caused by fuzzy notions of objects and phenomena; the student's activities are carried out under the guidance of the teacher;

Intermediate level: knowledge is incomplete, superficial, the student reproduces the basic educational material, but is not well understood, has problems with analyzing and formulating conclusions; capable of performing tasks on the model;

Sufficient level: the student knows the essential features of concepts, phenomena, patterns, connections between them, apply the knowledge independently in standard situations, knows how to analyze, draw conclusions, correct mistakes. The student's answer is complete, logically justified; understanding is related to single images, not generalized;

Advanced level: the student has a deep, solid, generalized knowledge of subjects, phenomena, concepts, theories, their essential features and the connection of the latter with other concepts; able to use knowledge in both standard and non-standard situations [30].

The analysis of the distribution of 9th-grade students by levels of educational achievement, shown in Table 6, showed that there were positive changes in all levels of academic achievement of students during the study of physics. Thus, the number of students with low educational attainment decreased by 10%; the number of students with an average level of educational achievement increased by 3.33%; the number of students with a sufficient level of academic achievement has increased by 3.34%; the number of students with a high level of academic achievement in physics also increased by 3.33%.

Table 6. Level of academic achievement of 9th-grade students at the beginning and the end of the pedagogical experiment

Stage of pedagogical experiment	The level of academic achievement of students in physics								Total students
	Low		Average		Sufficient		High		
	Num-ber	%	Num-ber	%	Num-ber	%	Num-ber	%	
Start	3	10,00	14	46,67	10	33,33	3	10	30
The end	0	0,00	15	50,00	11	36,67	4	13,33	30

The differences in the distribution of students by levels of educational achievement in physics are illustrated in diagram 6 (Fig.6).

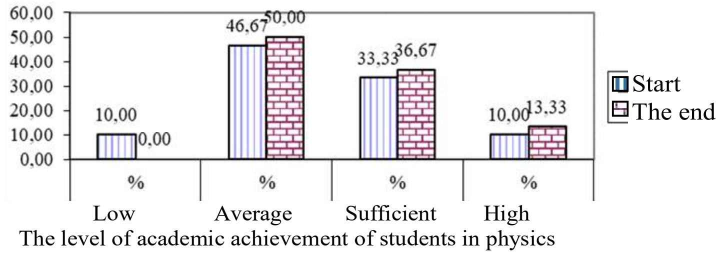


Fig.6. Distribution of 9th-grade students by levels of educational achievement in physics

The results showed that there were positive changes in the levels of educational achievement of students. The results were statistically substantiated using the T-Wilcoxon test.

So, the use of mobile technologies in Physics learning contributes to increasing the motivation of students' learning activities and enhancement of the level of educational material mastering.

4 Conclusions and Perspectives

The results of the research indicate that in the context of the active transformation of education in Ukraine, special attention should be paid to a variety of new learning methods, technologies, and techniques. The mobile technologies is a learning technology, based on the use of a wide range of digital and fully portable mobile devices (smartphones, tablets, e-books, etc.) that enable operations to receive, process and disseminate information; we propose to use it at general school, in particular, in Physics study.

The main ways to use mobile technologies in the process of teaching physics students are to use mobile applications, sites, services, cloud environments, web browsers while studying theoretical material, performing a virtual physical experiment, solving physical problems, completing homework, performing control measures (front-end polling, testing, etc.).

The prospect of further research will be development of our mobile application in physics, which will allow not only to interest students to study physics, but also to improve the quality of physical education of students.

References

1. UNESCO Policy Guidelines for Mobile Learning, Mark West, Steven Vosloo, (2013). Mode of access: https://unesdoc.unesco.org/ark:/48223/pf0000219641
2. Ukraine's Law "About Education". Mode of access: https://zakon.rada.gov.ua/laws/show/2145-19

3. United Nations Educational, Scientific and Cultural Organization. Mode of access: https://ru.unesco.org/events/mezhdunarodnyy-den-obrazovaniya-obrazovanie-glavnaya-dvizhushchaya-sila-inklyuzivnosti-i
4. Project of National Strategy for the Development of Education in Ukraine for 2012-2021. Mode of access: http://iitzo.gov.ua/files/proekt_rozvitku_osviti_2012_2021_.doc
5. The use of mobile technology in education/ Mode of access: https://naurok.com.ua/vikoristannya-mobilnih-tehnologiy-v-osvitnmu-procesi-120285.html
6. Moore, G. A. Crossing the Chasm, Marketing and Selling High-Tech Products to Mainstream Customer (revised edition), HarperCollins Publisher, New York, (1999).
7. Kirschner, P. A., van Merrinboer, J. G.. Do Learners Really Know Best? Urban Legends in Education, Educational Psychologist, 48:3, 169-183, (2013).
8. Traxler, J. Current State of Mobile Learning. International Review on Research in Open and Distance Learning (IRRODL), № 2, 8 (2007). Mode of access: www.irrodl.org/index.php/irrodl/article/view/346/875
9. Bykov, V. Yu. Mobile space and mobile-oriented Internet environment: features of model presentation and educational application, Information technology in education. № 17, 9-37 (2013).
10. Ky`slova, M. A., Semerikov, S. O., Slovak, K. I. Development of the mobile learning environment as a problem of theory and methodology of using information and communication technologies in education. Information Technologies and Learning Tools. Vol. 42. № 4, 1-19, (2014).
11. Trius, Y. V., Franchuk, V. M., Franchuk, N. P. Organizational and technical aspects of using mobile learning systems. Mode of access: http://enpuir.npu.edu.ua/bitstream/123456789/22949/1/Trius.pdf.
12. Compernolle, T. Brain released: How to prevent congestion and use your full potential, 749 (2015)
13. Lyashenko, O. I., Tereshchuk, S. I. Application of PLICKERS mobile technology in physics training. Vol. 72, №2, (2019).
14. Stryuk, M. I., Semerikov, S. O., Stryuk, A. M. Mobility: a systemic approach. Information Technologies and Learning Tools. Tom 49, №5, 37-70 (2015).
15. Stephanie Carretero, Riina Vuorikari, Yves Punie. DigComp 2.1: The Digital Competene Framework for Citizens with eight proficiency levels and examples of use. Luxembourg: Publications Office of the European Union, 48 p., (2017). (in English)
16. Krause, J. M., O'Neil, K., Dauenhauer, B. Plickers: A Formative Assessment Tool for K-12 and PETE Professionals. [online]. Mode of access: https://www.tandfonline.com/doi/full/10.1080/08924562.2017.1297751
17. Korobova, I., Goncharenko, T., Golovko, N., Hniedkova, O., Experience of Developing and Implementation of the Virtual Case Environment in Physics Learning by Google Services Proceedings of the 15th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer. Volume I: Main Conference / Kherson, Ukraine, June 12-15, 2019). p. 358-369. Mode of access: http://ceur-ws.org/Vol-2387/20190358.pdf
18. Semerikov, S. O. Fundamentalization education of computer science in higher education. 340 (2009).
19. Tereshchuk, S. I. Mobile learning technology: Problems and solutions. Mode of access: http://dspace.udpu.edu.ua/bitstream/6789/6914/1/VchdpuP_2016_138_40.pdf.
20. The official bulletin of national education. Mode of access: https://www.education.gouv.fr/bo/18/Hebdo35/MENE1826081C.htm?cid_bo=134400

21. Should Schools Ban Mobile Phones. Mode of access: https://learningenglish.voanews.com/a/should-schools-ban-mobile-phones-/5273391.html
22. Victoria State Government Education and Training. Mobile phones in schools (19 February 2020) Mode of access: https://www.education.vic.gov.au/parents/going-to-school/Pages/Mobile-phones-in-schools.aspx
23. Banning mobile phones in schools: beneficial or risky? Here's what the evidence says. Mode of access: http://theconversation.com/banning-mobile-phones-in-schools-beneficial-or-risky-heres-what-the-evidence-says-119456
24. Physics virtual lab Mode of access: https://play.google.com/store/apps/physicvirtuallab
25. Science Experiments In Physics Lab Mode of access: https://play.google.com/store/apps/
26. Physics at school Mode of access: https://play.google.com/store/apps/physicsatschool
27. Plickers Mode of access: https://get.plickers.com/
28. Get a class: Smart Mode of access: https://smart.getaclass.ru/exploration
29. PHUN Mode of access: https://play.google.com/store/apps/PHUN
30. Physics curriculum for students in grades 7-9 of secondary schools (2017, 2018, 2019).