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A B S T R A C T

of the dissertation for the degree of
Doctor of Philosophy in pedagogy

THE METHODOLOGY OF IMPROVING THE EFFICIENCY OF FORMING STUDENTS' KNOWLEDGE OF PHYSICS AND MATHEMATICS WITH THE APPLICATION OF MODERN INFORMATION TECHNOLOGIES

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GENERAL SPECIFICATION OF THE STUDY

Modern society is experiencing great changes related to the re-understanding of the scientific, political, and sociological situation. These changes occur in all areas of society, including education. The rapid development of telecommunications and information technologies, the formation of the global information space, imposes new demands on the modern society, mainly on the education system.

Information society building is being successfully continued in Azerbaijan as one of the main priorities of the state. The foundation of this policy was laid by our national leader Heydar Aliyev. At the millennium summit held by the UN in September 2000, it was recommended that all countries of the world adopt a relevant document on information and communication technologies in their national development strategies by 2015. Azerbaijan became one of the countries that responded quickly to this issue.

The President of Azerbaijan announced the development of information and communication technologies in the 21st century as a priority area in the socio-economic progress of the republic. Azerbaijan considers it extremely important to direct the revenues obtained from oil to the non-oil sector, including the application of high technologies, that is, information and communication technologies.

Starting from the 2017-2018 academic year, the implementation of the "Digital Skills" project was started in the general education schools of our country in order to ensure that students acquire ICT skills in depth, achieve their goal-oriented activity in the information space, and develop them as individuals with a competitive and logical way of thinking.

The main goal of the project was to improve the teaching of the subject "Informatics" and to apply a new approach to teaching the subject, to achieve the development of habits and competencies such as analytical thinking, logical thinking, 21st century knowledge and skills, coding, initiative, independent and team work.

Another successful project implemented in the field of education is the "STEAM Azerbaijan" project, which has been implemented since September 2019 with the support of the Heydar Ali-

yev Foundation. The project currently covers more than 6 thousand students in 42 schools of the country. The promotion of ingenuity, innovation and creativity among students is the main goal of the project, is one of the goals.

STEAM - The realization of new ideas as a result of the combination of Science, Technology, Engineering, Art and Mathematics is an educational approach that can help solve various problems in society. Critical approach, creative thinking, comparative understanding of acquired knowledge, consolidation of knowledge based on new projects in a creative form, collaboration, etc. as it forms 21st century skills.

In the 2020/2021 academic year, the introduction of Nanotechnology and Biotechnology modules to the educational content of the 7th grades, the introduction of a new platform (Arduino) in the direction of coding (Robotics), Flying devices (drones), skills of working on CNC machines, etc. designed.

After the pandemic was declared by the World Health Organization due to the widespread spread of the COVID-19 virus in 2020, as a result of the restrictions and closures imposed on mass events in the countries, it became necessary to fully implement distance education in schools and universities.

In addition to depriving students of the opportunity to study face-to-face, the pandemic also kept them away from school laboratories. So, problems arose in the teaching of many natural sciences. Physics, chemistry, mathematics, informatics, biology, etc. Conducting experiments used in the teaching of subjects, organizing visualization of problem solving was achieved through virtual laboratories. Information about such laboratories and examples related to the organization of lessons are given in Chapter 2 of the dissertation.

It is clear that the modernization of education goes through the computerization of secondary and higher schools. But first, such a pedagogical system should be established, in order to achieve the set goal, tasks should be prepared, more precisely, new technological programs should be created using computing techniques and communication tools.

Entering into all areas of human life, computers change not

only individual types of activities, but also the general activity of a person, and show their influence on all occurring mental processes. When a person interacts with new information technologies (computers, software, new types of mass media), activity mediated by new systems takes place.

In order to divide the management functions between the computer and the teacher, it is necessary to revise the organization of the teaching process. Informatization of training requires the solution of some problems, including the theory and practice of computer training and the development of computer programs to be used in teaching.

At the moment, the focus of researchers is on the didactic, psychological and pedagogical possibilities of applying information technologies of training in school. The possibilities of using the computer to increase the quality of the teaching methodology of some subjects have been investigated by many scientists (R.M.Aliguluyev, A.M.Mammadov, M.C.Mahmudov, A.Q.Palangov, I.N.Ismayilov, M.A.Alishov, Z.F.Kazimov, S.A.Zamanova, H.N.Taghiyev, R.Y.Shukurov, A.M.Gasimova, S.C.Taghiyeva, G.I.Bashirova, S.S.Hamidov, F.G.Safaraliyeva, M.V.Abdullayeva, T.M.Aliyeva, N.A.Abishov, Z.F.Babayeva, Kh.T.Novruzova, Russian scientists A.Vanyurin, A.Gurtova, E.Kuznetsov, E.Mamontova, K.Kolodko, V.Tikhamirov, L.Zakharova, etc.).

If we look at the educational system of developed countries, we will see that the problems we mentioned have already been solved to some extent in these countries. For example, Computer Science is not a Microsoft Word/Excel/Paint usage course. It is the study of algorithms, computational thinking, and immutable fundamentals. Almost all countries where Computer Science is implemented at the elementary school level (for example, Estonia, France, Israel, Spain, Slovakia, Great Britain, Finland, Poland, Portugal, partially USA, India, China, Australia) made a simple discovery - the program security training is a paradigm shift that occurred during the popularization of Microsoft Office, and as a result, a computer science teacher no longer needs to be an IT specialist, but rather a professional user.

But the software tends to become obsolete, and it is difficult to redevelop as quickly as the “user” as the “creator”. Based on this con-

clusion: The Computer Science program in UK schools (taken as a concrete example) consists of a set of blocks - algorithms, programming and development, data and their representation, hardware and processing, communications and networks, information technology.

In general, a number of countries have such a special feature - they have really undergone radical changes in relation to informatics. In the CIS, computer science is usually one lesson a week, and the level and status of the subject is at the same level as physical education, labor / technology class, music and dance.

What was done based on this conclusion: there is no universal answer. Somewhere, the state changed the requirements for subject teachers. For example, in Israel, all teachers were retrained, they began to demand that the teacher should not only be a good user of office programs, but also really know information technologies. Somewhere they increased the number of hours.

Learning computational thinking is first about learning the principles of thinking, and only then can you get behind the computer. Ironically, Australia and New Zealand have the most development in this direction - it is they who developed such a direction as CS unplugged - exercises to develop skills in a subject performed without a computer. Here's another insight - technology is often a distraction. Therefore, for example, it is recommended to first prepare presentations on a piece of paper/idea, summarize the main ideas and their order, and only then use power point and everything else. Studying computer science is just like that - first you need to understand the principles, then the technology.

In general, one feature is characteristic of most countries - they communicate a lot with teachers, principals and parents. So, I will once again give the example of Great Britain (in general, I think it is one of the most indicative and exemplary countries) - big TV channels are involved in the implementation of the new course, “how to help your child learn computer science”, “yourself what is important to know for” and etc. active support was given at the level of articles such as.

Relevance and degree of development of research. When characterizing the current state of the current process, it is clear that

our republic lags far behind developed countries in this field, including Russia. This is mainly due to the lack of material bases, technical means, and the low level of training of teaching staff. The use of information technologies in the teaching of many subjects, including mathematics and physics, is not widespread enough. Hopes in this area have almost not come true.

The level of preparation of school graduates does not meet the requirements of the rapidly developing science, technology, and economy. The traditional teaching methodology in schools is rightfully criticized for its formality, i.e., for its focus on memorizing teaching material and imparting uniform knowledge and skills.

In this regard, contradictions appear in the education of high school students:

− between the new person who can meet the requirements of the modern information society, that is, who knows information technologies and has creative thinking, and the possibilities of the modern school in this field;

− between the excellence of the information technology content of the training and the lack of scientific research in this field;

− between the students' demand for information technologies in learning subjects and the insufficient preparation of teachers.

The object of the research is the process of organizing the teaching of physics, mathematics and informatics in the upper grades of general education schools with a new method.

The subject of the research is the study and implementation of new opportunities for the application of ICT tools in physics, mathematics and informatics classes in upper classes.

Research goals and objectives. The purpose of the study is to increase the efficiency and quality of the knowledge of upper-class students in the study of physics, mathematics and informatics subjects by applying information technologies of training, to create maximum interest in the lesson in students, to ensure the visibility of the problems prepared through various application and programming languages, assimilation and quality of the acquired knowledge and skills. is to achieve an increase in interest rates.

The following **tasks** have been set before the scientific re-

search conducted to achieve the goal:

1. Solving the problem of improving the quality in the study of mathematics, physics and informatics subjects of high school students;

2. To conduct a historical-pedagogical analysis of the development of information technologies of training;

3. To broadly analyze and define the concept of "educational information technologies";

4. To ensure the teaching of issues included in the curriculum and which are relatively difficult for students to understand through computer programs, for this purpose, with the help of programming languages, to build a program of some issues included in the curriculum, laboratory experiments, to use these software packages and electronic textbooks during the lesson;

5. Prepare an evaluation mechanism that determines the learning qualities of high school students in mathematics, physics and informatics;

6. To prove through experience the increase in the quality of education of mathematics, physics and informatics subjects as a result of the use of information technologies.

As **research methods**, complex methods - observation, comparison, generalization, experiment, statistics, analysis-synthesis, induction and deduction, interactive and other active learning methods were used to solve the problems and check the initial hypotheses.

In order to determine the directions of the research, a survey and survey was conducted in schools in 2017-2019.

The main provisions defended:

1. Disclosure of the structural and functional characteristics of information technologies, the necessary conditions for their use (the form of dialogic communication between the subjects of the educational process; changing the formula "student → teacher → book" to the formula "student → computer → teacher"; formulating tasks "from simple to complex"; maximum visuality and comfort; creation of positive motivation in learning natural sciences; self-examination) ensures the mastering of mathematics, physics and informatics educational programs at an optimal level;

2. In order to improve the quality of training, when using infor-

mation technologies of training, both positive and negative effects of these technologies on the psychology of students should be taken into account as a necessary condition (positive effect: active participation of the student in choosing the dominant directions of the form and speed (pace) of training; with the help of educational multimedia programs thanks to the organized interactive exercises, heuristic content (a system of logical and methodical methods of theoretical research) increases; creativity and self-assertion are easier than traditional methods. Negative effect: reduction of the possibility of eliminating stress situations and nervous-psychological tension during the educational process, exchange difficulties caused by replacing “subject” with “object”; narrowing of creative cognition, etc.);

3. The quality criterion of mathematics, physics and informatics training developed by us (complete-practical, cognitive activity and independence, motivated, emotional-volitional) helps to determine the quality and level of assimilation of educational material;

4. With the help of various types of programs developed by us, the methodology of solving mathematical problems and the programming of some experiments from physics activate the students' cognitive activity, form a positive motivation for creative thinking and reading. It also innovates both content and teaching of computer science.

The scientific novelty of the research is that:

− a didactic system of forming the habits of using information technologies in the teaching of mathematics, physics and informatics in secondary schools was developed;

− an explanatory interpretation of the concepts of “educational information technologies” and “educational computer technologies” is provided;

− the classification and typology of information technologies of training in the study of technical and natural sciences (classification reflecting mutual relations) was carried out;

− for the first time, modern software packages were included, and lesson samples were prepared for mathematics, physics and informatics classes in accordance with the curriculum requirements from the software packages;

− a model of laboratory work in mathematics, physics and in-

formatics was developed using electronic resources.

The theoretical importance of the research is determined by the main provisions of the methodology of didactic research (S.S.Hamidov, A.S.Adygozelov, M.C.Mahmudov, I.N.Ismayilov, V.Krayevskiy, M.Skatkin), information technologies and systematic approach in education (A.G.Palangov, H.N.Taghiyev, R.A.Mahmudzade, I.C.Sadigov, A.Matrosov, N.Talizina, E.Polat, E.Mashbits, etc.), measurements in pedagogical research (S.Alizade, P.Atamanchuk, L.Zakharova, T.Kirillova, V.Lazaryev and others), theory of problem-based learning (F.A.Rustamov, I.Isayev, A.N.Abbasov, H.H.Ahmadov, I.Lerner, V.Maksimova), technological bases of the design and organization of the educational process (S.Mammadov, A.A.Azizova, V.Monakhov, V.Bespalko), the methodology and theory of teaching mathematics (M.A.Alishov, Y.Bakhshaliyev, O.Yelisheva, A.Stolyarov, L.Fridman) and they are the following:

−the content and structural components of the concept of “educational information technologies” have been clarified;

−the demand for the use of information technologies in the teaching of mathematics and other sciences - the demand for a systematic approach is justified.

The practical significance of the research is that:

−the reasons influencing the increase of students' interest in learning new subjects, their free work, and their activeness in the teaching of mathematics, physics and informatics subjects were explained;

−the method of using software packages in the teaching of mathematics, physics and informatics has been worked out by the author, some problems of physics and mathematics have been programmed, sources and methods of use have been shown for conducting laboratory works by computer.

Approval and application: Dissertation work in the seminar held at the Department of Computer Sciences of the Azerbaijan Pedagogical University, Physics, mathematics and informatics teaching in the Scientific-theoretical and methodical collection, Pedagogical University News, Institute news (Azerbaijan Teachers' Institute), in Voronezh: Перспективы развития современно школы» scientific journal, In the scientific journal “High School of Kazakhstan”,

Azerb. Resp. Speeches in the Scientific Publication of the Educational Institute "Scientific Works", Severo-Caucasian Mining and Metallurgical Institute I International Scientific and Practical Conference, Kazakh National Pedagogical University named after Abaya, at the Republican scientific conference dedicated to the 98th anniversary of the birth of H.Aliyev organized at the Western Caspian University and approved and applied in the form of articles.

The dissertation work was performed at the **Institute of Information Technologies of ANAS**.

The total volume of the dissertation with a sign indicating the volume of the structural sections of the dissertation separately. The dissertation consists of an introduction, 4 paragraphs covering two chapters, 5 clause, a conclusion, a list of used literature and appendices.

Introduction 12 pages, 21365 sign, Chapter I 53 pages, 95637 sign (1.1 – 12 pages, 21977 sign; 1.2 – 17 pages, 28896 sign; 1.3 – 15 pages, 27660 sign; 1.4 – 9 pages, 16984 sign), Chapter II 69 pages, 78999 sign (2.1 – 21 pages, 22148 sign (2.1.1 – 9 pages, 7099 sign; 2.1.2 – 7 pages, 9202 sign); 2.2 – 18 pages, 16405 sign (2.2.1 – 6 pages, 6629 sign; 2.2.2 – 5 pages, 3414 sign); 2.3 – 23 pages, 32509 sign (2.3.1 – 10 pages, 12108 sign); 2.4 – 7 pages, 7871 sign), result 3 pages, 4782 sign, literature the list consists of 12 pages and appendices of 15 pages, the dissertation consists of 166 pages, 200783 characters.

THE MAIN CONTENT OF THE STUDY

The first chapter is called "Theoretical foundations of the application of modern information technologies in the teaching of mathematics, physics and informatics". This chapter consists of 4 paragraphs: different approaches to the concept of "educational information technologies"; Information technologies of training and their psychological-pedagogical features; Characteristics of the use of information technologies in the teaching of natural sciences in secondary schools; The place of the problem in the scientific-methodical literature.

In the first paragraph of the first chapter, the current state of quality in the study of mathematics, physics and informatics sub-

jects of high school students was studied, the historical-pedagogical analysis of the development of information technologies of training was carried out; The concept of “educational information technologies” has been broadly analyzed and defined.

In the definitions given to the concept of “educational information technologies”, two main approaches are more common. In the first approach, it is proposed to look at the information technologies of training as the sum of the didactic process and the pedagogical technique of the teacher in the use of the computer, the effective way to achieve the goal set in mastering the subject, the possibility of monitoring the result at all stages. In the second approach, it is about the creation of a certain technical environment of the training, in which the used information technologies take the main place. In the first case, the computer plays a leading role as the main tool in creating a special educational environment, and in the second case, modern information technologies (computer) are used as an auxiliary work tool.

Thus, in the first approach, we are talking about the information technologies of training, and in the second, the application of information technologies in training.

There is another approach proposed in 1985 and 1986 - the information technology of training is the use of training programs on the basis of electronic computing machines. It should not be forgotten that in those years the application of computers to the educational process was just beginning, and educational programs were practically the only information technology. In the modern era, the rapid development of computing and communication technologies has made more sophisticated information technologies available, and the above approach has almost merged with the first approach.

The information technology of training involves the use of special methods that include programmed training, intelligence training, expert systems, hypertexts, multimedia, microworld, simulation of training. These special methods should be used depending on the purpose of teaching. In some cases, deep understanding of students' needs, in some cases the analysis of the knowledge gained in the training of a certain subject, and in other cases, the consideration of the psychological principles of training takes place.

“Computer technologies of education” means pedagogical software tools that model a part of the teacher's function in the teaching process and are implemented with computer equipment and telecommunication tools. “Information technologies of training” means a methodical-program system based on computer and telecommunication technologies, interactive software tools, supporting modern training technologies.

In the second paragraph of the first chapter, information technologies of training and their psychological-pedagogical features were investigated.

When teaching computer technologies with the help of educational programs, there are several levels of dialogue between a machine and a person according to the degree of activity: reactive, active, interactive. The organization of these dialogues in the teaching process has been mentioned. The most difficult thing in the development of educational programs is the ability to correctly choose the pedagogical directions of these programs. The pedagogical directions of the programs have been determined:

- conceptual (the goals and objectives of the training are determined);
- pedagogical (methodology of conducting computer lessons is prepared);
- technological (the interaction of various management components is envisaged);
- practical (creating a bank of teaching material at a level that meets the purpose of the training);
- input into the machine (entering into the computer's memory dialogues that take into account different levels of learners, bank of educational materials, updating as necessary).

Three ways of eliminating the negative situations caused by information technologies have been proposed.

1. Each operation of computer training programs should be psychologically justified.
2. Must have a high level of proofreading in terms of content.
3. Game forms of training should be used.

After getting acquainted with the research of many scientists

about computer psychology, the following factors that cause stress during work with a computer can be cited as an example:

1. When the computer reacts too late to human commands;

2. Due to difficulties in mastering a new program or when switching from an old program to a new one;

3. When there is a problem with the operation of the software ("freezing").

KG Krechetnikova devoted her research work to the impact of information technology on students' intellectual activity.[1] Here, the impact of the computer on psychological health and mental development is considered. Special attention was paid to the explanation of the term "Internet-addiction", and three ways of eliminating the negative situations caused by information technologies were proposed. Let's take a look at the proposed ways:

I. Psychological justification of each operation of computer training programs.

For example, when including the process of problem solving in the educational program, the following psychological-pedagogical requirements are imposed:

1. The system of issues should guarantee the assimilation of adequate knowledge, there should be no possibility of false information creating psychological consequences;
2. It is possible to solve the problem when the subject is fully mastered;
3. The problem solving algorithm mastered with the help of the educational program should be optimal;
4. Issues related to various topics should be presented randomly during the exercise;
5. Problems of the same level of difficulty must have the same probability of presentation;
6. Adaptation should be taken into account when solving problems of different degrees of difficulty;

[1] Krechetnikov, K.G. Influence of information technologies on intellectual activity of students: [Electronic resource] / K.G.Krechetnikov, – http://science.donntu.edu.ua/links/socio.html

7. At least 50 pieces of each type of the proposed questions should be prepared;

8. All issues must be diverse in terms of content;

9. In order to inculcate analysis, 10% of the issue related to the topic to be studied should be included;

10. It is necessary to try to have no answer options as much as possible so that there is no possibility of finding a random answer.

II. Having a high level of proofreading activity in terms of content.

The learner needs special preparation for self-management of the comprehension process. As a result of this preparation, users of information technologies should be able to prepare educational programs by themselves, using the rich resources in the educational environment, and choose the appropriate one from the types of training.

III. Using game forms of training.

In the third paragraph of the first chapter, the characteristics of the use of information technologies in the teaching of natural sciences in secondary schools were considered. The basics of the functional structure of conditions of use of information technologies are indicated:

- Communication between the subjects of the educational process is in the form of dialogue;
- Changing the formula "Student → teacher → book" to "student → computer → teacher";
- Strengthening the verification of the understanding of knowledge;
- Tasks "from simple to difficult", maximum visual and convenient
- Formation of increased interest in learning subjects;
- Self-check.

The first software packages for mathematics appeared 10 years ago. Among them, Russian production "1С: РЕПЕТИТОР. МАТЕМАТИКА" complex, the electronic textbook "Открытая математика 1.0 Планиметрия и стреометрия" produced by the company "Физикон", the electronic textbook "Functions and graphs", "Algebra 7-11", "Planimetry 7-9", "Stereometry 10-11" electronic text-

books, etc. can be shown. Although the Russian version of the electronic textbook “The Geometer's Sketchpad” dedicated to dynamic geometry “Живая геометрия” and the program “Stella” dedicated to the modeling of ecological and economic dynamic systems are widely distributed abroad, they are still rarely used in Azerbaijan.

Currently, in Russia, a new type of electronic edition of mathematics called “Obrazovatelnýy kompleks Математика 5-11” has been produced by the “1C” company. There are 5 “laboratories” (planimetry, stereometry, algebra, algorithm and probability theory, mathematical statistics), verbal calculation simulator and various information materials.

One of the distinctive features of this system is that ready-made issues are not stored in the system, but are created as a result of the original technology in unlimited numbers and each time with a different composition. The solution of these issues is also demonstrated in an explanatory manner. The student can enter the answer to the question in any way (formula, number, written) and it is not counted as an error as in some other systems. The teacher can use the checking mode at any time both during the lesson and after the lesson. A problem on any topic can be selected and printed on a printer and distributed to students as homework. In this case, although the issues are similar, they are not repeated.

Electronic publications in the Azerbaijani language published in our republic include biology, history, physics, mathematics, etc. encyclopedic textbooks prepared on subjects can be cited as an example. In addition to mathematics, there are educational multimedia programs for many subjects. For example, multimedia lessons on biology for grades 6-11 have been developed in Microsoft PowerPoint.

An electronic textbook “Astronomy – 3000” has been prepared for studying astronomy. Here, the author organized lessons related to each studied subject through multimedia slides. In the “Astronomy” electronic edition, preference was given to modeling. The program consists of a control file and 6 main programs: 2 computer models of the solar system (terrestrial planets and giant planets), a model of the movement of celestial bodies, a galaxy, a view of the galaxy from the center of the solar system, and an observer's view of the stars. The proposed

complex significantly improves the quality of teaching astronomy.

The electronic textbook "Открытая физика 2.5" in teaching physics includes 14 computer laboratory works and various test tasks.

Electronic textbooks of physics and astronomy are fundamentally a new pedagogical-program product. Unlike other multimedia resources, there are no ready-made hypertexts. The teacher has the opportunity to search and obtain the necessary materials from the database and create interactive models with minimum text, maximum graphics, animation, and video fragments.

Mathematics teachers can also use ready-made computer systems, Matlab and MathCAD, in the classroom.

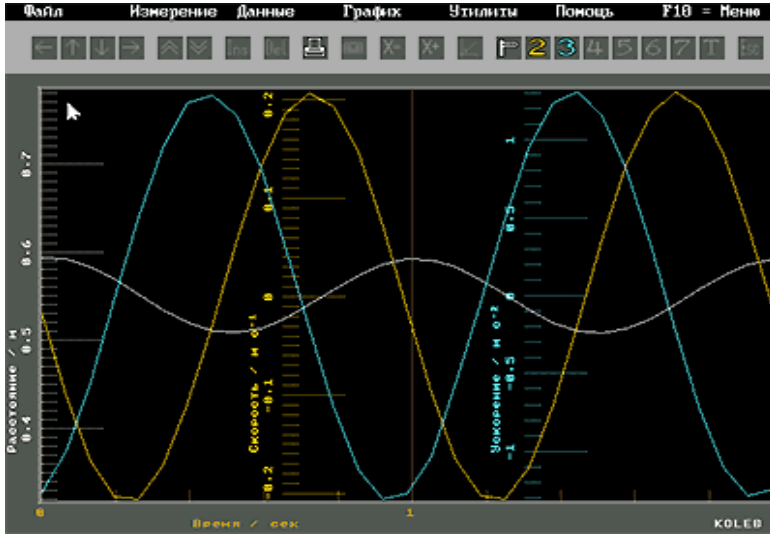
In the fourth paragraph of the first chapter, the place of the problem in the scientific-methodical literature is investigated. We reviewed the scientific methodical literature that is important for research in our republic and noted their importance for our research, but we also commented on their shortcomings. It turned out that some research works are related to the problem we set, but in terms of purpose, content, object, etc., it is necessary to develop a completely different research work. To justify this opinion, we looked at the works of well-known Methodist scholars of the republic.

The second chapter is called "Ways of applying information technologies to the educational process". It consists of four paragraphs: "Ways of applying information technologies in teaching physics", "Ways of applying information technologies in teaching mathematics", "Computer models and their importance in teaching informatics", "Pedagogical experiment and analysis of its results".

In the first paragraph of the second chapter, the ways of applying information technologies in the teaching of physics were considered. Various topics in the physics textbook are programmed, laboratory works are visualized through ready-made software packages. (video of two laboratory works is attached).

For example, while studying atmospheric pressure, several students go up or down with a pressure measuring device, depending on where the physics cabinet is located, then return to the cabinet, the device is connected to the computer, the file is read by the computer, and the time graph of the pressure, that is, the graph of the height de-

pendence, appears on the screen. After this experience, there is no need to give an additional explanation to the students, that is, to understand the increase and decrease of pressure due to height. They witness it with their eyes. Or when studying the law of free fall, harmonic oscillation movements, the device is still connected to the computer, and graphs of dependence of all physical quantities are automatically displayed on the screen (Pic. 1).



Picture 1. Graphs of time dependence of coordinate, speed, momentum of harmonic oscillation movements

In the second paragraph of the second chapter, the ways of applying information technologies in the teaching of mathematics were considered. Algebra and geometry problems were solved with the help of different software packages, and the algorithm for solving geometry problems was visualized. (video attached).

We have shown solutions to several issues in the Excel program:[2]

[2] Shabanova, S.A. Solving some mathematical problems in the Excel program // - Baku: Physics, mathematics and informatics teaching, - 2007. No. 1, - p. 66-72

1. **Numerical differentiation**

Using the numerical approximation method, it is possible to calculate the derivative of the function at a given point using the finite difference method.

The formula for calculating the derivative of a one-variable function by the finite difference method is as follows:

$$F(x)=\frac{\Delta F}{\Delta x}=\frac{F(x_{k+1})-F(x_k)}{x_{k+1}-x_k}$$

We will use this formula when calculating the derivative of a function in Excel.

Example 1. Calculate the derivative of the function Y= 4x3 + 3x2 at x=2.

When solved analytically, the value of the derivative of this function at the point x=2 is 60.

To solve this problem in Excel, you need to perform the following sequence.

- Let's write the value of the argument of the given function around the point x=2 with a step of h=0.001 and the value of the derivative corresponding to those points in the form of a table (Pic. 2).

	A	B	C	D	E
1	x	y	y'	=(B3-B2)/(A3-A2)	
2	1,997	43,8202	59,8651		
3	1,998	43,8801	59,919		
4	1,999	43,94	59,973		
5	2	44	60,027		
6	2,001	44,06	60,081		
7	2,002	44,1201			

Picture 2. Derivative values

- Let's write the derivative formula in cell C2. Here, cell B2 receives the value xк+1, and cell A2 receives the value xк.
- Up to the 7th line, we transfer the formula by tug and get all the values of the derivative corresponding to the argument.
- At the value of x =2, the derivative of the function is equal to

the value of 60,027.

In the third paragraph of the second chapter, the ways of applying information technologies in the teaching of informatics were considered. A lesson model was built in the database, the teaching of the algorithm was visualized through the program, a calculator system was built and the transition in different number systems was visualized (video is attached).

In the fourth paragraph of the second chapter, the pedagogical experiment and its results were analyzed.

Pedagogical experiment The work started in 2010-2011 was analyzed, and the obscure ways of the research were clarified. The name of this stage was also called the defining stage, as the goal was to determine the directions of the research. Here, the theoretical and methodological basis of solving the problem set for the main purpose of the research is defined. Here, certain assumptions on the conduct of the research were determined, provisions were established according to these assumptions, and work was carried out on the basis of it. Then, the availability of ICT tools in selected secondary schools was studied. It was checked whether there are favorable conditions for conducting experiments in schools.

Exemplary programs of ICT tools have been developed for teaching natural science subjects in classes where experiments are planned. During the experiment, the list of topics of the methodological system proposed was given to the teachers of the experimented classes. The scenario of the methodical system that we claim for the lesson was also given to them. The teachers working in the control classes were informed only about the purpose of the experiment. They were not given any additional information about the methodical system to be conducted.

The experiment was conducted in secondary school No. 236 of Binagadi district of Baku city, secondary school No. 7 named after Nizami Ganjavi in Sheki city, secondary school No. 2 of Guba district, Samadabad settlement secondary school of Bilasuvar district. A preliminary check was carried out to determine the experimental and control classes, and the levels were expected to be mostly equal across the classes.

The second phase is called the educational phase and covered the academic years 2013/2014. At this stage, it is dedicated to teaching the rules of the methodical system. Here, programs, textbooks, curriculum documents, integration and planning tables were used for the use of ICT according to the topics to be taught with the new system. The ICT tools to be used, including the rules of the methodical system developed for their use, are given and recommended for study. With this, the teachers of the experimental classes were introduced to that content and methodology.

A significant part of the material used at this stage of the experiment was selected from currently used textbooks and teaching aids and additional literature, and the method of use was shown.

In order to conduct training in experimental classes with our proposed methodology, an exemplary scenario of lessons on topics has been prepared.

The third phase of the pedagogical experiment covers the 2015/2016 academic years and this phase is called the verification phase. At this stage, a system of questions and studies on the topics taught during the experiment was drawn up. On the basis of this, inspection works were carried out. Several intermediate inspections were conducted here, their results were checked and analyzed. At the end, a final inspection was conducted and the result was analyzed.

The obtained results are not spontaneous, but analyzed by a statistical method. The following markings and rules are defined for the statistical analysis of the results:

Let's take a look at the methodology of the experiment we conducted: a test consisting of questions and tasks corresponding to the topics taught in the classes we choose is organized. It is considered that these questions and tasks should be the same in control and experimental groups. The results are checked and compared. If the results in the experimental group are higher than the results in the control groups, then the methodology we have developed shows its effectiveness. In such a case, the teaching method is continued in the schools we have chosen, and the decision to start implementing it in other schools on a large scale in the future is being reviewed.

At the preliminary stage of preparation, all teachers were fami-

liarized with the goals and tasks of the experiment, the essence of the experiment was explained to them, and the prepared methodical works were given to them for their use. In the course of the experiment, the proposals, recommendations and notes of the teachers were also carefully examined and those that served the ideas of the research were taken into account. In order to prepare the teachers for conducting the experiment, seminars were held with them on the following topics:

"Methodology of teaching some subjects of physics with the application of ICT tools", "Methodology of teaching some subjects of mathematics with the application of ICT tools", "Methodology of teaching some subjects of informatics with the application of ICT tools", "Active learning technologies and the possibilities of using them in the teaching of informatics", "ICT system of studies in the study of informatics with the application of", "Characteristics of methodical recommendations that serve to conduct experiments", "Goals, organization and content of pedagogical experiments".

The teachers participating in the experiment were provided with appropriate instructions on conducting the experimental training in time.

Physics of students studying in secondary general education schools located in different regions of the republic during the period when the determining experiment was conducted. The level of existing knowledge and skills in mathematics and informatics has been determined.

The selection of groups for experiments was made on the basis of observation of the training in the first half of the training year. The students answered specially designed questions and performed the exercises.

In the experimental groups, the training was based on the implementation of research ideas, and in the control groups, it was conducted in a traditional manner.

The students' level of knowledge (percentage of mastering the answers to questions and exercises) was calculated based on the following formula and summarized in the tables given in the dissertation:

$$M_1 = \frac{\sum X}{N_1}100; \qquad M_2 = \frac{\sum X}{N_2}100$$

Here: knowledge level of M1 and M2 students, $\sum X$ – correct answers; and N_1 və N_2 – is the number of students.

The following formula was used to check the efficiency (effectiveness) of the methodology we determined:

$$U_{ef.} = \frac{P(+) - P(-)}{N} \cdot 100\ \%$$

Here: $U_{ef.}$ – is an efficiency indicator;

$P(+)$ – shows the number of correct answers;

$P(-)$ – the number of wrong answers;

N – the number of students.

Methodology of the experiment: both the experimental and control groups are tested on the basis of the same material. The results of experimental groups and control groups are compared. If a high level was achieved in the experimental groups, those results are applied in secondary general education schools that were not involved in the experiment, and if a good result is obtained there, mass application is allowed.

Programs, textbooks, curriculum documents, integration and planning tables were used for the use of ICT according to the topics to be taught with the new system. The ICT tools to be used, including the rules of the methodical system developed for their use, are given and recommended for study. With this, the teachers of the experimental classes were introduced to that content and methodology.

The selection of groups for experiments was made on the basis of observation of the training in the first half of the training year. The students answered specially designed questions and performed the exercises. In the experimental groups, training and research was carried out based on the implementation of ideas, and in the control groups, it was conducted in a traditional manner

When comparing the knowledge level of the students of the experimental class and the students of the control class, it became clear that the mastery level of the students of the experimental groups was

13.4 to 22.4 percent higher than the students of the control class, and the efficiency was **11.6 to 24.5 percent** higher, respectively.

Conclusion: The study of the problems of pedagogical conditions that affect the quality of acquisition of physics, mathematics and informatics by high school students, the analysis of the experience of applying these tools at school, and the results of the conducted pedagogical experiment gave reason to say the following:

1. The application of ICT tools in new ways in the study of mathematics, physics and informatics subjects by high school students increases the quality of mastering the subjects.

2. It is necessary to ensure the teaching of the issues included in the curriculum and which are relatively difficult for students to understand through computer programs, for this purpose it is necessary to build a program of some issues included in the curriculum and laboratory experiments with the help of programming languages, and to use these software packages during the lesson.

3. As a result of the use of information technologies, it has been proven through experience that the quality of education of mathematics, physics and informatics subjects has increased.

4. Disclosure of the structural and functional characteristics of information technologies, the necessary conditions for their use (the form of dialogic communication between the subjects of the educational process; changing the formula "student → teacher → book" to the formula "student → computer → teacher"; formulating tasks "from simple to complex"; maximum visibility and comfort; creation of positive motivation in learning natural sciences; self-examination ensures mastering of mathematics, physics and informatics educational programs at an optimal level.

5. In order to increase the quality of training, both positive and negative effects of these technologies on the psychology of students should be considered as a necessary condition when using information technologies of training. The quality criterion of mathematics, physics and informatics training developed by us (complete-practical, cognitive activity and independence, motivated, emotional-will) helps to determine the quality and level of mastering the educational material.

6. With the help of various types of programs developed by us, the methodology of solving mathematical problems and the programming of some experiments from physics activate the students' cognitive activity, form a positive motivation aimed at creative thinking and reading. It also innovates both content and teaching of computer science.

20 scientific works have been published on the subject of the dissertation. Of them, 15 articles were published in peer-reviewed scientific journals, and 5 reports were published in materials of international and national conferences.

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