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METHODOLOGICAL JOURNAL**<http://mentaljournal-jspu.uz/index.php/mesmj/index>**USING COMPUTER MODELS OF PHYSICAL PHENOMENA IN TEACHING  
PHYSICS IN A MODERN EDUCATIONAL INSTITUTION  
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**ABOUT ARTICLE**

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**Abstract:** In recent years, a new approach to teaching, using educational computer simulations, has gained popularity, particularly in the teaching of physics and technology. This study proposes an innovative concept for implementing a teaching approach using educational computer simulations at a university. This is done to ensure continuous learning and interdisciplinary opportunities for students. The study examines the development of natural skills and knowledge in the context of computer simulations. The study also describes the principles of collaborative learning, which are key pillars for the acquisition of cognitive and research skills. The contribution of computer simulations to learning is further linked to the improvement and development of thinking. After outlining the theoretical foundations, the article examines teachers' views on the application of computer simulations to teaching. The advantages and disadvantages of computer simulations in teaching are also discussed.

**Introduction.** Today, physics teachers face a number of challenges: a constant reduction in hours for natural science subjects, declining funding for the educational process, and the wear and tear of existing equipment. Combined with increased demands on the knowledge of graduates and increased student workloads, these difficulties can develop into insurmountable problems. The solution to these problems can be found in the use of modern, intensive forms, methods, and teaching aids. For example, the use of problem-based learning, model hypotheses, and the use of television and video equipment in the teaching process will improve the quality of knowledge and reduce the psychological burden on students. The use of computer technology in the teaching process can also help solve these problems. The use of computer models of various physical processes and phenomena enhances the effectiveness of physics learning, allowing students to understand the mechanisms of physical phenomena, particularly those processes that are invisible to the human eye and, in some cases, impossible to implement in practice and in real life.

#### 1. Classifications of models and their importance in teaching physics

Computer models play a significant role in teaching physics. They build on students' previously accumulated preliminary understanding of physical phenomena, which may not be accurate at the beginning of their physics studies. Throughout the physics course, these models expand and broaden students' horizons. They foster correct initial understanding of new physical phenomena and processes, reveal patterns, and introduce research methods. Demonstrating models develops students' attention and memory while studying various phenomena and patterns. Computer models can also serve as a starting point for explaining a topic, illustrating and accompanying a teacher's story, discussion, explanation, or lecture; and confirming what has been stated. Models of physical phenomena are also used to pose experimental problems and (in rare cases) for questioning students and reviewing material covered. A model is a representation of objects (items, phenomena, or processes) in the real or imaginary world and their properties [1]. Typically, a model does not possess all the properties of an object, but only those necessary for studying it. For example, an airplane model differs from the real thing in size and may differ in detail. A model is needed to:

- imagine an object, reproduce its appearance and characteristic features;
- understand how a specific object is structured, what its structure is, the main
- properties, laws of development and interaction with the surrounding world;
- learn to control the object;
- predict the consequences of impact on an object, etc. [1-3]

Based on these goals, the result of modeling may be a simplified likeness of a real object, a reproduction of an object in a reduced or enlarged form—i.e., its model. Physics deals with real and abstract objects. Information in the real world is embodied in various physical processes. To study and represent these processes using computers, special abstract (formalized) models are used; i.e., models of real objects are used instead of their real counterparts. A mathematical model is a mathematical relationship or system of mathematical relationships reflecting the essential properties of an object. A graphical model is a graphical representation of objects. Examples of graphical models include a drawing of a component, a diagram of a device, a floor plan of an auditorium, or a geographic map. A tabular model is a representation of the properties of objects and processes in a table. For example, the process of gas compression in a vessel under a piston can be represented as a table of changes in pressure and volume over a certain period of time.

Computer simulation is the modeling of objects, processes, and phenomena using specialized computer programs: graphic editors, animation editors, spreadsheet programs, database creation programs, specialized computer simulators, and virtual laboratories. Simulators are software and hardware that create the impression of reality, simulating the operation of a vehicle, apparatus, or device, reproducing some of the real phenomena and properties in a virtual environment [4-6].

## 2. Benefits of introducing computer models into the educational process

Using computer technology to manage the educational process and scientifically organize work will help teachers organize the educational process, prepare for lessons, and conduct extracurricular activities in physics. This approach involves creating an information and reference system that could include an electronic journal, electronic report card, and a catalog of literature and physical equipment used in the educational process. Furthermore, the teacher can create an electronic library of physics problems, demonstration experiments, and lesson plans that can be edited on the fly. By creating such an information retrieval system and defining the criteria by which information will be retrieved, teachers can significantly facilitate lesson preparation, report creation, analysis of student performance and attendance, etc. Furthermore, a computer can be invaluable in a teacher's research work, systematizing and summarizing available information. A computer, as an innovative teaching tool, is a new assistant in the learning and development of children of all ages. The main advantages of introducing computer models into the educational process include:

- increasing the accessibility of education, with the expansion of forms of education;

- development of personally oriented learning;
- creation of a unified information and educational learning environment;
- independence of the educational process from place and time
- providing the ability to choose an individual trajectory
- development of independent search, including creative, activities of the student;
- increasing the motivational side of learning;
- development of the student's personality, preparing him for life in the information society;
- increasing the visibility of training;
- automation of control processes;
- automation of psychodiagnostics and others.

It should be noted that any rationally designed model, taking into account not only the specifics of the content information but also the psychological and pedagogical patterns of assimilation of this information by students, will not, by itself, ensure the quality of instruction and the improvement of the educational process. The main thing in its implementation, as with any teaching tool, is the goals and methods of organizing classes, which the teacher must consider before incorporating new teaching tools into the educational process [7]. Currently, a sufficient number of ready-made tools have been developed that allow the creation of modern, sufficiently flexible digital teaching and control tools, modeling and demonstration programs, websites, electronic textbooks, and much more, which provide the teacher with the following opportunities:

- prepare diverse information (theoretical and demonstration material, practical tasks, questions for testing);
- to formulate a scenario for creating a specific digital learning tool;
- significantly reduce the time for preparing digital educational resources and conducting classes (group control);
- implement your methodology for presenting material and teaching through the created digital educational resources.

**Materials and methods.** The primary goal of implementing computer models is to create a learning environment for students to work independently, at their own pace, and with the class. Using models of physical phenomena in physics teaching opens up enormous opportunities for developing fundamentally new forms and methods of preparing students for further education.

### 3. Equipment of the physics room

Equipping a physics classroom is currently a complex and important task. To meet all educational standards and regulations, a wide range of teaching equipment is required: stands, laboratory furniture, visual aids, and much more. Equipping a physics classroom is also a top priority for faculty, who are committed to ensuring that physics is a favorite subject for students. The challenge lies in the fact that physics classrooms cover a variety of subjects: mechanics, optics, electricity, thermodynamics, molecular physics, and much more. Consequently, each subject must be presented to students in a way that stimulates interest and ensures that each subject is fully understood and understood. This requires a modern physics classroom that provides students with the full opportunity to engage, experiment, listen, memorize, and, most importantly, understand. Due to the high cost of physics classroom equipment these days, it is difficult to acquire, which is why not all schools have it.

A modern classroom should enhance the effectiveness of the learning process and facilitate independent and creative student activity. A classroom cannot be created overnight. It is built gradually, updated, and improved over several years. However, classroom equipment that enables effective teaching of the subject must meet certain requirements [8-11]. After analyzing teachers' articles about the state of physics classrooms, the following conclusions can be drawn:

- For a number of years, the material and technical base of the physics room has not been updated;

- the existing equipment is outdated and does not meet modern requirements;
- there is no office decoration (stands, computers).

Along with this, the following disadvantages can be noted:

- there is a large amount of faulty equipment and outdated technical training aids that are subject to write-off;

- lack of long-term plans for the development of physics classrooms;
- weak use of electronic teaching aids in the educational process, lack of computer equipment;

- insufficient provision of equipment for all sections of physics.

Fundamentally new information carriers are currently being introduced into teaching practices. For example, a significant portion of educational materials, including source texts, sets of illustrations, graphs, charts, tables, and diagrams, are increasingly being placed on multimedia rather than printed media. This makes it possible to distribute them online and create a classroom library of electronic products. A well-equipped physics classroom facilitates the effectiveness of educational experiments and enables the comprehensive use of various

teaching aids in lessons, leveraging their functionality. Summarizing the literature devoted to the consideration of physics classroom equipment, the following can be highlighted: all the functions assigned to a demonstration experiment (ensuring, in accordance with the scientific method of cognition, the observation of phenomena, the formation of concepts, the measurement of physical quantities, the establishment of functional relationships, the study of processes, and the experimental verification of physical laws, hypotheses, and theoretical conclusions) can be realized with an optimal combination of digital measurement instruments and computerized measurement systems with classical ones. The new equipment makes it possible to fully implement a system of experiments necessary for the formation of concepts and the introduction of physical quantities [12].

Based on this, it can be said that classes become more enjoyable and engaging with the use of modern technology. Students' adherence to rules of conduct is more easily achieved when they are engaged in the educational process. The depth of study of physics largely depends on student interest, which in turn is facilitated by the availability of various physics microlaboratories, interactive teaching aids, experiments, suitcase labs, and much more, making the learning process more engaging and vibrant. Therefore, given the difficulties of equipping physics classrooms, a computer is becoming an assistant. Its use can help introduce new topics, conduct demonstration experiments, and review previously studied phenomena without violating safety regulations. It can also replace experiments involving electricity, fire, cutting and piercing objects, glassware, and other objects, thereby preventing accidents [13].

#### 4. The need to use computer models in teaching physics

Information technology is one of the most important tools in education, so developing a plan for its development and use in education is a key issue. Consequently, the use of computing technology is becoming increasingly important. Many experts believe that computers will enable a qualitative leap forward in the education system. Two main areas of computerization are typically distinguished. The first aims to ensure universal computer literacy, while the second utilizes computers as tools to enhance learning effectiveness. Educational activities are divided into two types: teaching and learning. If a computer manages learning activities, it can be considered a teaching tool, replacing the teacher, as the computer simulates learning activities, asks questions, and responds to students' answers and questions like a teacher. If a computer is used solely as a tool for learning activities, its interaction with students is similar to that of a "computer user." In this case, the computer is not a teaching tool, although it can impart new knowledge. Therefore, when discussing computer-based learning, what is meant is the use of a computer as a tool for managing learning activities. The computer expands the

capabilities of the experiment: observation of fast-moving phenomena, obtaining oscillograms of processes, obtaining and analyzing a large set of data, modeling phenomena that are impossible for a number of reasons in real conditions [14].

Didactic principles are understood as certain obvious initial assumptions that any educational process must satisfy, i.e., the axioms of education and learning. They are understood as the initial assumptions underlying the selection of content, organization, and implementation of the learning process. These are the normative foundations based on known patterns of the learning process and reflecting the specific features of the organization of teaching and learning processes, taking into account the psychology of learners.

Let us dwell in more detail on the tasks that can be achieved by introducing a computer into the educational process:

- To develop students' creative abilities, the ability to analyze, model, predict, and think creatively.
- Increase interest in the study of physics.
- To improve students' practical skills in working on PC.
- To develop students' ability to acquire knowledge independently by working with educational programs on a computer.
- Implement a differentiated approach to students when teaching physics using a computer.

Electronics and computing technology are becoming components of physics curriculum, tools for optimizing and increasing the effectiveness of the learning process, and contribute to the implementation of many principles of developmental learning. The introduction of modern educational and information technologies into the educational process will allow teachers to:

- develop the depth and strength of knowledge, consolidate skills and abilities in various fields of activity;
- develop technological thinking, the ability to independently plan their educational and self-educational activities;
- build an individual learning trajectory for each student;
- to develop habits of strictly following the requirements of technological discipline in the organization of educational activities.

The introduction of computers has significantly impacted educational activities; today, no one disputes the thesis of the necessity of using computers in the classroom. Moreover, the current state of physics teaching requires their use in physics lessons. A significant number of

computer models, covering almost the entire school physics curriculum, are contained in educational electronic publications: "Physics in Pictures," "Open Physics," and "Living Physics." There are extensive possibilities for modeling physics problems in the MS Excel environment [15]. Programming languages are the software environment for computer modeling. Studying the literature on this topic, one can note that many methodologists once wrote: "Computerization is proceeding at such a pace that in a few years computers will be in every school. Therefore, it is precisely now that it is necessary to develop methodological recommendations for the use of computers in lessons, as well as justifications for interdisciplinary interaction.

"First of all, it is necessary to create electronic educational programs that must correspond to the university curriculum, and methodological manuals for their use, electronic textbooks, problem books, tutors with a convenient and understandable interface for everyone" [16]. Much of the above is already available in many institutions; now teachers just need to master all of this and learn how to apply it, including electronic teaching aids in their lessons [17]. One of the most promising areas of using information technology in physics education is computer modeling of physical processes and phenomena. Computer models easily fit into a traditional lesson, allowing the teacher to demonstrate many physical effects on the computer screen, and also make it possible to organize new, non-traditional types of educational activities. With the correct use of computer models of physical phenomena, it is possible to achieve much of what is required for the informal assimilation of a physics course and for the formation of a physical picture of the world. The computer is an assistant to the teacher in such unfavorable conditions as:

- lack of interest in the subject among students, when they believe that they will not need physics in the future;
- lack of ability to study the exact sciences;
- lack of laboratory equipment at school to demonstrate the experiment.

A computer can be used at all stages of the learning process: explaining (introducing) new material, reinforcing, reviewing, and monitoring. For the student, it serves various functions: as a teacher, a work tool, a learning object, a collaborating group, and a leisure (game) environment. When choosing a whole-class format for teaching, it is useful to use various libraries of electronic visual aids and presentations based on them on the lesson topic. The use of computer models of physical phenomena in the educational process has its undeniable advantages in many cases. They allow for a new perspective on the phenomenon being studied, provide more complete information about changing physical quantities, construct

corresponding graphs and trajectories, "observe" the processes being studied dynamically, develop a visual image of the phenomenon being studied in students, gain insight into its physical essence, and obtain answers to questions that remain open as a result of conducting a real experiment.

Computer models can be used either when explaining the relevant material or when repeating and reinforcing the material.

It can be concluded that a computer can be used at all stages of the learning process: explaining (introducing) new material, reinforcing, repeating, and monitoring. It performs various functions for the child: as a teacher, a work tool, a learning object, a collaborating group, and a play environment [18-21]. When solving such problems, a computer can perform a control and demonstrative role. Its control in solving experimental problems consists of monitoring the sequence of actions associated with conducting an experiment or measurements. By entering the results of experiments or measurements into a computer database, it is possible to obtain an illustration of the physical phenomenon or process being investigated in the problem. The illustration can be in the form of a model of the process or phenomenon, a diagram, a graph, or a chart, confirming the correctness of the solution or reasoning.

#### 5. Using a computer in the experiment

There are three possible ways to use a computer during a physics laboratory experiment:

- The computer is used to process measurement results and measurement errors, and to plot graphs or diagrams.
- The computer controls the laboratory equipment.
- The computer program completely simulates the process being studied, takes measurements and plots graphs.

Let's take a closer look at each of the available options. Using a computer to process the results of laboratory work and physics practical exercises. This approach allows for greater focus on the substantive aspects of laboratory work and physics practical exercises, experimental analysis, and the development of practical skills. This is possible by reducing the time students typically spend on mathematical calculations, especially when making approximate calculations.

The use of a computer in laboratory practice can be carried out in three stages:

- Admission to perform work - can be carried out in the form of a test control of knowledge of how to work with laboratory equipment, the progress of the work, and theoretical material related to the experiment being conducted.
- Automation of the measurement process – as mentioned above, using a computer for experimental research. This method can be used as a basis for performing measurements in school labs.
- Results processing – two options are possible. First, the computer can be connected to the lab setup, and results processing occurs as experimental data is received. Second, results processing can occur after the students enter the data into the computer. With either option, parameters are calculated based on the measurements, compared with tabulated values, experimental results are analyzed, recommendations are issued, and a graph or diagram is plotted.

For secondary school students, the most practical way to calculate laboratory experiment results is with the multifunctional interactive computing system Mahtcad . Its built-in algorithms allow for the analytical and numerical solution of a large number of problems without programming. This program has a user-friendly interface and excellent 2D and 3D graphics, as well as the ability to connect to office and design programs, as well as the Internet. If the laboratory work requires plotting graphs based on measured physical quantities entered into a table, Excel can also be used, although the graphs will be very approximate. Simple calculations can also be performed there. Other programs, such as Mathematica , Matlab , and Maple, can also be used for certain calculations and plotting graphs, but their use requires some basic programming knowledge. Experimentation always serves as the foundation and criterion for scientific achievements in physics. With the development of scientific and technological progress, the volume of information increases, experimental techniques become more complex, and the requirements for their final results increase. This creates difficulties in managing experimental equipment. This circumstance has led to the need to create automated scientific research systems (ASRS). Each such system is based on the use of a computer, but the principles of computer use can vary.

**Results and discussion.** In the simplest cases, an experiment only collects information by measuring and recording the values of various physical quantities. Data analysis and processing occur after the experiment is complete. Such systems can only be used for relatively slow processes. Furthermore, the researcher typically controls the experiment manually. If the experiment is relatively fast and requires processing its results during the experiment itself, it makes sense to automate the process using a computer. The greatest efficiency in conducting a

scientific experiment can be achieved by processing all incoming data during the process being studied. High computer performance allows us to hope that all aspects of the phenomenon being studied will be captured, and if the experiment deviates from the pre-planned schedule, necessary adjustments can be made promptly.

Physics experiments play a significant role in the educational process. It is recommended that at least 30% of physics lessons be devoted to laboratory work, using active physics teaching methods: research, problem-based, exploratory, etc. Often, the active use of laboratory experiments in physics teaching is due to the lack of necessary physical equipment; sometimes, the experiment cannot be carried out without specially created conditions. A solution to this problem has been found in virtual laboratory work. Although they are merely a model for real-life laboratory work, they nevertheless allow for a fairly in-depth study of physical phenomena or laws in some cases, as they can be used to pose problems to students that are often difficult or even impossible to solve in a real-life experiment [22].

This type of activity is closely related to computational experimentation or modeling.

#### 6. Using a computer in problem solving lessons.

Of great importance in teaching problem solving is the development of students' skills:

- Analyze the conditions of the problem and model the situation;
- Create and implement a plan to solve a problem;
- Analyze the obtained result;
- Transfer the found solution to a series of similar problems;
- Plan activities to apply theoretical knowledge.

In this regard, when solving problems, a computer can be used:

As a means of obtaining additional information about the situation in the problem being solved, the content of the actions included in its solution: modeling, visual demonstration, reference information.

To organize the students' activities for independent compilation of a complete indicative basis for the activity

Solving problems using a computer is carried out in stages:

- Statement of the problem.
- Drawing up a solution algorithm.
- Programming.
- Carrying out calculation.

Basic principles of using computers to solve physics problems:

- relative freedom of the student;

- automatic adjustment of the difficulty level of the tasks being solved in the event of an inadequate assessment by the student of his/her capabilities;
- full individualization of tasks using a random variable generator to generate data for a specific task;
- automatic analysis of errors made by students when solving problems, determining their causes, followed by issuing appropriate recommendations based on repetition of theoretical material;
- implementation of an objective final assessment of the quality of the student's solution to the problem with a documentary analysis of all the mistakes made by him, for complete and comprehensive information to the teacher, recording and archival storage of the results of the work;
- Mandatory referral to the teacher in cases where a student cannot master the educational material and acquire the skills and abilities to solve problems as a result of communicating with a computer.

Taking these principles into account, one can determine the possibilities of using a computer in the educational process to solve physics problems:

- when consolidating new material by solving problems;
- to carry out ongoing monitoring of the development of techniques, methods and skills for solving problems;
- for independent mastery of the material;
- to develop creative thinking, skills and abilities in solving non-standard problems;
- when rewriting tests without a teacher at any time convenient for the student;
- for independent work in preparation for tests, final and entrance exams.

#### 7. Database of existing computer models

Educational programs that can be used in teaching physics can be divided into modeling, computational, testing, and reference [23]. Modeling programs are those that present the user with a computer model of a physical phenomenon or object. They can be used when demonstrating the phenomenon or object itself is impossible due to its high cost, low visibility, or danger to life. Computational programs are designed to process and interpret experimental results. Such programs can perform complex calculations for students, construct graphs and diagrams, and are especially effective when combined with measurement modules, such as the L micro. Testing programs ensure knowledge verification through testing or step-by-step problem solving. They are characterized by objectivity and impartiality. Reference programs

are databases and data banks that provide students with access to reference educational information [24].

Let's consider computer models as the most common computer-based educational programs. The advent of personal computers a quarter century ago ushered in a new era of computer use in education, and since then, numerous computer models have been created. These models were created by professional programming teams, teachers, and lecturers, as well as students. Such programs cover a wide range of phenomena and objects, and vary in their comprehensiveness, quality, scope, systematicity, and clarity.

8. Study of surveys aimed at collecting students' opinions on the effectiveness of using computer modeling

To study and determine the most effective method for teaching physics laboratory work, a survey was developed to gather students' opinions on the effectiveness of teaching laboratory work using both traditional (in-person) and modeling (simulation) methods. One physics course, "Physics (Mechanics)," was selected for this study. Table 1 presents the experiments performed by students, along with links to them.

**Table 1. Experiments performed by students of the Phys-24-25 course.**

| Table 1. Experiments performed by students of the Phys -24-25 course |                        |
|----------------------------------------------------------------------|------------------------|
| Experiment                                                           | Physics                |
| Speed and acceleration                                               | Movement               |
| Forces in nature                                                     | Vectors                |
| Law of conservation of momentum                                      | Pulse                  |
| Rigid body dynamics                                                  | Dynamics               |
| Torques and balance                                                  | Equilibrium            |
| Centripetal force                                                    | Roundabout Circulation |

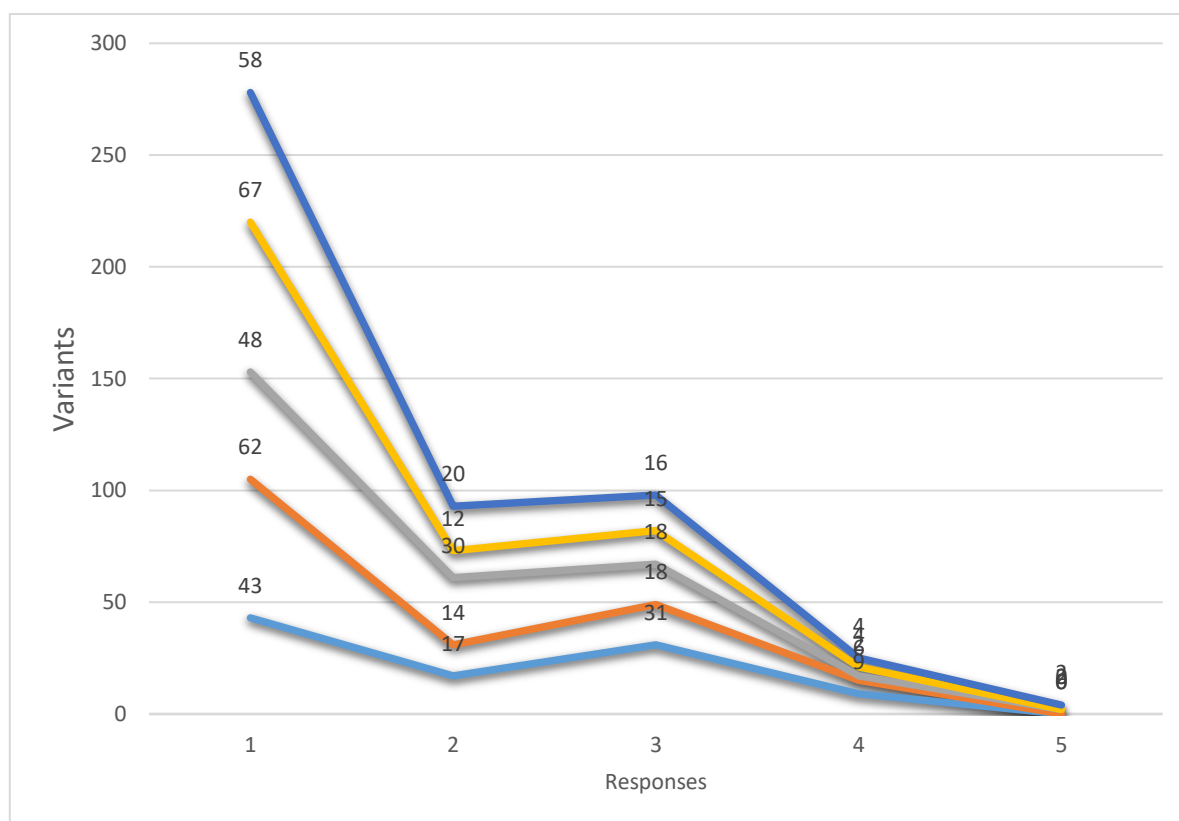
The survey was available to students online after they completed the lab and conducted all experiments. Half of the experiments were traditional, and the other half were simulated. Two experiments were selected, and our students worked on them using both the traditional and simulated methods. Our students completed six different standard experiments, following the lab manual (Table 1). Table 2 contains a preliminary survey designed to gather students' opinions on the effectiveness of lab instruction using both the traditional and simulated methods. The survey results are presented in Table 2 and Figure 1.

**Table 2. Results of the Phys-2 5 -2 6 survey**

| Table 2. Results of the Phys-2 5 -2 6 survey |         |   |   |      |   |   |
|----------------------------------------------|---------|---|---|------|---|---|
| A                                            | Options | A | B | WITH | D | U |

|   |                                                                                                  |    |    |    |   |   |
|---|--------------------------------------------------------------------------------------------------|----|----|----|---|---|
| 1 | Modeling experiments have expanded my knowledge and concepts beyond traditional ones.            | 43 | 17 | 31 | 9 | 0 |
| 2 | Model experiments are more interesting than usual ones throughout the simulation                 | 62 | 14 | 18 | 6 | 0 |
| 3 | The advantage of modeling is that it can be easily repeated several times to verify the results. | 48 | 30 | 18 | 2 | 2 |
| 4 | It is necessary to make wider use of model laboratories in teaching.                             | 67 | 12 | 15 | 4 | 0 |
| 5 | Model laboratories should become part of traditional laboratories.                               | 58 | 20 | 16 | 4 | 2 |

Note: A - Agree; B - Completely agree; C - Neutral; D - Disagree; E - Completely disagree;  
in percent %



**Figure 1. The Bar Diagram for the Survey Results for Phys-2 5 - 6**

The main findings of the survey can be summarized as follows:

- 43% of students surveyed agreed that computer experiments expanded their knowledge of the material covered in class more than traditional experiments (31% neutral, 9% disagree).
- 62% of students agreed that simulation experiments are more interesting and attract their attention more than traditional ones (18% neutral, 6% disagree).

- 48% of students indicated that the most noticeable advantage of computer simulation experiments is the ability to repeat any part of the simulation to better understand and verify the results obtained (18% neutral, 2% disagree).

- 67% of students agreed that computer experiments should be used more in teaching (15% neutral, 4% disagree).

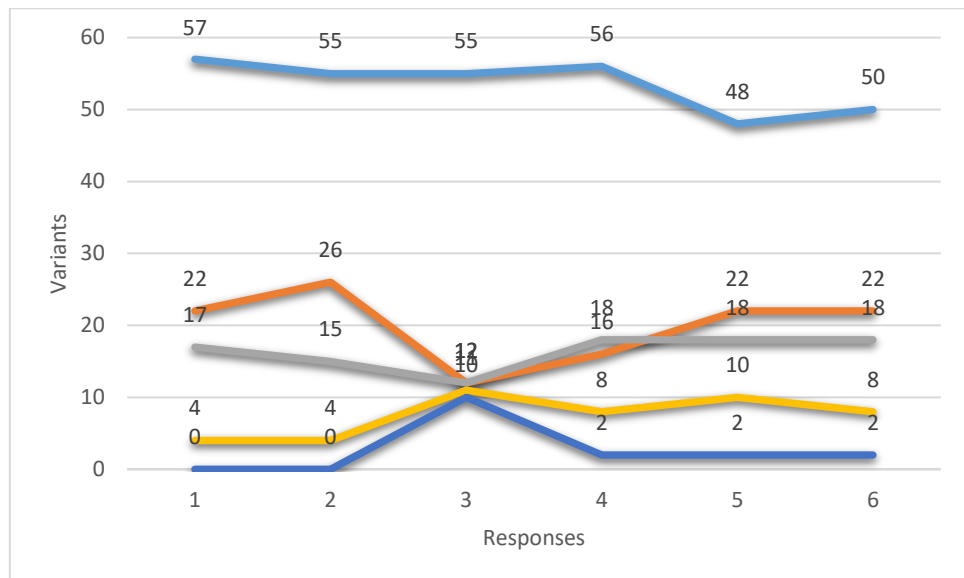
- 58% of students agreed that computer labs should be part of traditional labs (16% neutral, 4% disagree).

Handouts for all experiments were provided to conduct the simulation experiments. These materials contained instructions for conducting the simulation and several questions (both theoretical and model-based). The questions were designed to assess students' understanding of the material. Table 3 shows a preliminary survey designed to gather students' opinions on the effectiveness of teaching laboratory work using both traditional (in-person) and simulation ( computer-based ) methods .

**Table 3. Results of the Phys-2 5 -2 6 survey**

| Table 3. Results of the Phys-2 5 -2 6 survey |                                                                                                        |    |    |      |    |    |
|----------------------------------------------|--------------------------------------------------------------------------------------------------------|----|----|------|----|----|
| I<br>N                                       | Options                                                                                                | A  | B  | WITH | D  | E  |
| 1                                            | Simulations improved my understanding of the theory                                                    | 57 | 22 | 17   | 4  | 0  |
| 2                                            | Working with simulations makes lab classes more engaging than regular ones.                            | 55 | 26 | 15   | 4  | 0  |
| 3                                            | Conducting simulation experiments gives me a real sense of the phenomenon                              | 55 | 12 | 12   | 11 | 10 |
| 4                                            | Computer simulation labs are easier to monitor than traditional labs.                                  | 56 | 16 | 18   | 8  | 2  |
| 5                                            | The computer simulation lab inspired me to create scenarios that were different from traditional ones. | 48 | 22 | 18   | 10 | 2  |
| 6                                            | Make greater use of computer simulations in the laboratory                                             | 50 | 22 | 18   | 8  | 2  |

**Note: A - Agree; B - Completely agree; C - Neutral; D - Disagree; E - Completely disagree; in percent %**



**Figure 2. The Bar Diagram for the Survey Results for Phys-2 5 -2 6**

- 57% of students agreed that large-scale simulation experiments improved their understanding more than traditional experiments (17% neutral).
- 55% of students agreed that the similarity of simulation experiments to real-life scenarios makes them more engaging than traditional experiments.
- 55% of students agreed that computer experiments give them a feeling of being part of an experiment compared to traditional ones (12% neutral, 8% disagree).
- 56% of students said that computer experiments were easier to follow and conduct than traditional experiments (18% neutral, 4% disagree).
- 48% of students agreed that the simulation experiments encouraged them to create scenarios other than those in the lab handouts (creativity) (18% neutral, 10% disagree).
- 50% of students agreed that there is a need to make greater use of computers laboratory simulations (creativity) (22% neutral, 8% disagree).

#### 9. Results of the study of surveys on the effectiveness of teaching laboratory work

Students' responses indicate that they prefer computer simulation experiments for many reasons:

- Deeper understanding is achieved through students' ability to explore many of the theoretical concepts covered in lectures in a short time using simple simulation models.

Computer /simulation experiments are much more engaging to work on due to the similarity of their scenarios to real-world experiences, especially if the experiments require a large space. This can be emphasized by encouraging students to create their own additions to the simulations.

- Students' ability to repeat the simulation until they gain greater understanding.

- The results obtained through simulation have fewer errors due to the precise computer tools used by students (measures, scales, etc.).

- The simulations are easy to use and execute due to their similarity to the video games that most students play.

- Gifted students began to think of new scenarios that could be added to the simulations, and this resulted in a deeper understanding of the theory.

Survey results demonstrated this, and our students were able to better understand physics concepts without being constrained by space/time constraints. Simulations make learning engaging and enhance student engagement with the material, which significantly impacts collective student achievement in each experiment. Simulation laboratories bring physics principles closer to the real world by maximizing the experimental scenarios' resemblance to real-life examples, and they also motivate and engage students. They stimulate the creativity of many students, allowing them to consider adding additional capabilities to the simulation, which will enhance learning [22-24].

**Conclusion.** This paper examines and analyzes the benefits of integrating computer models (CM) into the educational process. During the course of teaching practice, lesson plans were developed using computer models of physical phenomena, which were then used in the lessons. The analysis demonstrated that the use of computer models in lessons improves the quality of education due to the novelty of the activity. Thus, it can be concluded that an important role of information technology is in enriching the content of educational material with computer models. They are essential for students' assimilation of new material or reinforcement of existing material, making lessons more detailed and varied. While perceiving and understanding a new topic, participants can observe physical phenomena represented using various models. All this makes the lesson more engaging and understandable. Based on the above, it should be noted that the proper use of computer models of physical phenomena can achieve much of what is required for informal assimilation of a physics course and for the development of a physical picture of the world. Therefore, it can be concluded that the use of computer models in teaching physics increases the student's interest in the subject, his academic performance and the quality of assimilation of educational material.

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