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Methodological Recommendations for the Development of Creative Competence of Future Physics Teachers Based on Digital Educational Tools

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Abstract. The article addresses the enhancement of creative competence among future physics teachers through the integration of digital educational tools, a pressing issue in contemporary educational technology. It highlights how innovative didactic models and methods can foster creativity in both teachers and students during lessons. The current challenges in physics education necessitate effective solutions, particularly in accurately assessing student knowledge and establishing supportive competencies. The incorporation of computer technology and electronic exhibitions into physics instruction offers students a more engaging and accessible understanding of complex topics. This paper emphasizes the significance of electronic exhibitions in physics lessons, showcasing how digital education can facilitate the exploration of scientific concepts through practical examples and mathematical frameworks. By utilizing issues and graphs, virtual laboratories, and computer modeling, these technologies enhance the teaching of fundamental physics laws and principles. Ultimately, the article advocates for the adoption of digital tools in physics education to improve learning outcomes and prepare future educators for the demands of modern teaching environments.

INTRODUCTION

The effectiveness of digital learning tools in the process of students learning physics is that students can get the information they need using tools such as interactive textbooks, virtual laboratories, simulations, and multimedia presentations, in which the science is easy to learn. and enables clear understanding, development of logical thinking, conducting practical training, and development of mutual cooperation [1]. When solving problems in physics, it is appropriate if control questions and problems are created based on the sequence of all sections of physics [2]. This article shows that it is important to recommend the effective use of digital educational tools in order to improve the creative competence of future physics teachers and to acquire new information in order to further enrich their knowledge in the educational processes of students [3]. In all aspects of the educational process, to increase the scientific activity and creativity of learners and educators, and to increase the effectiveness of the educational process, the use of digital educational technologies, that is, the competence of working with information development is in the first place in many developed countries and a lot of experience has been accumulated in this regard [4]. There are several software tools for teaching physics, some examples of which can be given [5]. PhET Interactive Simulations, Physics Classroom, Khan Academy, Wolfram Alpha, MyPhysicsLab, physics at school, etc. [6]. It allows to organize the educational process using software tools, to increase students' interest in science, to acquire new knowledge, to strengthen their knowledge, to exchange experience and to establish cooperation [7]. The use of computer programs in physics lessons allows physics teachers to learn all the programs and use them effectively [8], [9].

By analyzing different approaches and methods, this study seeks to highlight the advantages and limitations of using computer software in the field of physics.

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METHODOLOGY

Competence is a set of knowledge, skills and abilities that a person needs to achieve goals and solve problems. Competence consisting of abilities, knowledge and experiences aimed at increasing creativity is called creative competence. Creative competence includes the ability to acquire new knowledge and find solutions to problems, generate new ideas and conclusions, apply concepts in new directions, and find convenient and innovative solutions to problems [6]. Creative competence is considered to be very important in developing the ability to discover innovations and innovations, and to manage mastered tasks. Creative competence is very important for people, because it is demanded by the change of society and developments in the field of technology [7]. It is important to use software tools in science teaching to facilitate access to research materials and enhance practice.

RESULTS AND DISCUSSION

The following software tools are widely used in teaching physics:

1. Simulation programs: This program allows students to calculate models and systems of processes in molecular physics by computer, to turn theoretical knowledge into practice, to study various physical processes. The Physics Education Technology (PHET) site, created by Nobel laureate physicist K. Wiman, has models on a variety of topics, created in Java (and in HTML5 formats). The models presented on the PHET site can be used as open source (Open Source) as desired. The number of models in PHET is more than 167 and they consist of modeling programs related to Physics, Mathematics, Chemistry, Biology and Earth Sciences. This program is an important pedagogical tool due to its compliance with state educational standards and the literature used in educational institutions [8]. The main features of this program are: interactivity, ease of learning, comprehensive and easy to use. The feature of interactivity makes it easier for students to learn scientific knowledge [9]. Learning Facilitation Feature: Provides interactive tools to facilitate the transfer of scientific knowledge from theory to practice. The comprehensive nature of PhET programs covers topics from all branches of physics, allowing students to have a variety of experiences in these topics. Ease of use: PhET programs are available for free on an online platform and can be accessed via a computer, tablet or mobile device. Through these features, students' learning processes are facilitated. Using the PhET program in teaching molecular physics helps to study the structure of molecules, their interactions, chemical processes, reaction processes. PhET Interactive Simulations: https://phet.colorado.edu/.
2. Interactive textbooks: Interactive textbooks provide facilities for students to easily understand and learn physics topics. These textbooks are provided with graphic, animation, audio and video materials. It works through textbooks, online platforms or programming language for early devices (eg computers, tablets). For example, the Physics Classroom program provides students with interactive tutorials, tests, skills, and tips. The "Physics Classroom" program provides good opportunities for students to test their knowledge in online exams of various levels and to self-evaluate. The main features of this program are: textbook, articles, problems and tests, multimedia materials, study guides. Physics Classroom: https://www.physicsclassroom.com/.
3. Virtual laboratories: Virtual laboratories are virtual platforms and programs that give students the opportunity to perform physical science practices, conduct experiments and solve physical problems [10]. For example, in the "Labster" program, students will have the opportunity to practice through virtual laboratories. This program gives students the opportunity to study physics experiments in laboratories [11]. "Lansber" program was defined in 2012. There are more than 300 virtual laboratories in this program, which provide facilities for students to experience scientific processes, study scientific research, and strengthen theoretical skills. Important features, virtual laboratory experience, interactive and 3D, user friendship, scientific research. Labster: https://www.labster.com/.
4. Online Platforms: These platforms provide students with access to learning materials through online classes, webinars, tutorials and additional information. At the same time, it allows students to have the necessary information at their own time and place. Education and training platforms include Coursera, Udemy, Khan Academy, edX, Skillshare. The Coursera platform is one of the popular online learning platforms. Through this platform, students can apply for classes, courses and certificate programs prepared by teachers based on the program. The Udemy platform offers courses in various fields that allow students to gain additional knowledge in the areas that interest them. The Khan Academy platform provides education in different languages in different subjects. It helps students to develop in various fields selected according to their goals.

The edX platform works in partnership with several famous universities and educational institutions, such as Harvard, MIT, UC Berkeley, and others. Students can receive a certificate by actively participating in classes and courses prepared by these universities. In addition, the "MyPhysicsLab" program provides an opportunity to understand and test the laws of physics in all departments of physics, mechanics, molecular physics, electricity and magnetism, and other departments on this online platform [12]. Teachers and students can get the necessary training manuals and textbooks using the MyPhysicsLab program. Another convenience of using this program is that it can be used from a mobile device through the mobile application of the program. This makes it possible for them to access various simulations from mobile devices as well. Simulations can be used to explore data, view images and draw graphs, update data, and perform other functions. Important features of "MyPhysicsLab" are: Interactivity, participation, various physics topics, ease of use. MyPhysicsLab: https://www.myphysicslab.com/.

5. 3D models and animations: 3D models and animations are widely used in several fields. For example, education, animation films, programming, design, and other fields. The role of 3D models and animations in education is to visually represent learning materials and enable learners to see, understand and think. It facilitates teaching and learning processes in subjects such as physics, chemistry, biology, mathematics, etc. In understanding theoretical information in physics, movements and physical processes are taught through 3D models and animations. There are several types of 3D models and animations, and in the study of molecular physics we mainly use "Static models", "Kinematic animation", "Dynamic animation". "Static Models" are used to represent static 3D objects, i.e. just photos, "Kinematic Animation" is used to represent objects that move and can control themselves after interaction, and "Dynamic Animations" are used to represent objects that move and interact. 'secret' is used to describe objects that cannot control themselves. This helps to visually explain skills to students. The main features of this program are: Visual emphasis, interactivity, ease of learning processes, remote learning, technical development.
6. Quizzes and interactive tests: These software tools are a good tool to test students' knowledge of physics and enhance their independent learning. They include solving tests, solving questions and submitting. Mainly, the Khan Academy and GeoGebra programs were developed for testing and solving graphics, geometry, algorithmic and physics problems. The Khan Academy platform was founded in 2008 by the manager Salman Khan, and it includes high-quality video lessons, exercises on various topics, examples and preliminary practical exercises, exams and assignments of various levels. Khan Academy offers programs in various disciplines to develop students' skills in various fields. "GeoGebra" is an interactive program mainly adapted for scientific research. It allows teachers and students to study scientific researchers using mathematical methods. Through this program, you can learn to create and modify mathematical functions and expressions, graphs and diagrams, equalities, inequalities and algebraic operations. It is used not only in mathematics, but also in the study of various branches of physics. Main features: control of knowledge level, opportunity to experiment, speed and convenience, explanation, motivation.

In the rapidly developing field of physics, the use of computer programs as a means of solving complex problems is becoming more and more widespread. These programs, which use mathematical algorithms and simulations, have proven to be very effective tools for physicists. Computer programs play a crucial role in solving physics problems due to their ability to handle complex calculations and simulations. These programs provide physicists with a simplified approach to analyzing and modeling physical phenomena, allowing them to learn theories and predict outcomes. In addition, computer programs allow optimization and automation of repetitive tasks, saving valuable time and effort. The accuracy and efficiency of these programs make them an invaluable tool in the pursuit of scientific knowledge and progress in the field of physics.

One of the popular methods of using computer programs to solve physics problems is simulation. In the rapidly developing field of physics, the use of computer programs as a means of solving complex problems is becoming more and more widespread. These programs, which use mathematical algorithms and simulations, have proven to be very effective tools for physicists. This essay aims to explore the various techniques used by physicists in using computer software to solve physics problems. By analyzing different approaches and methods, this study seeks to highlight the advantages and limitations of using computer software in the field of physics. In addition, numerical methods play a decisive role in solving physics problems with the help of computer programs. These methods involve approximating the solutions of mathematical equations by dividing them into discrete steps and using iterative processes. Numerical methods allow researchers to simulate complex physical phenomena that cannot be solved analytically, which enhances the understanding and prediction of various experimental results. In addition, the use of numerical methods in physics helps develop computational models that can simulate realistic scenarios and analyze large data sets.

Simulation software allows physicists to create virtual environments that mimic real-world conditions and the laws of physics.

The Monte Carlo method can be defined as a method of modeling random variables to calculate their distribution characteristics. It is used to solve problems in physics, mathematics, economics, optimization, control theory and other fields. In physics-related problems, Monte Carlo methods are useful for simulating systems with many degrees of freedom, such as fluids, disordered materials, strongly bound solids, and cellular structures. In statistical physics, Monte Carlo methods are used to calculate statistical field theories of simple particle and polymer systems. In quantum physics, Monte Carlo methods solve the many-body problem for quantum systems. In experimental particle physics, Monte Carlo methods are used to design detectors, understand their behavior, and compare experimental data with theory. In astrophysics, they are used in various ways to model galactic evolution and the transmission of microwave radiation through a rough planetary surface. Monte Carlo methods are also used in the ensemble models that form the basis of modern weather forecasting.

In this article, we will review some basic theories of quantum mechanics and the double-slit experiment. We now use the power of Monte Carlo techniques to deal with the probabilistic nature of quantum mechanics. We take the last two parts of this article and combine them to simulate a two-slot Monte Carlo experiment. First, we define the probability function of a particle present somewhere in the viewing window.

We will not consider the complete derivation of the Fraunhofer diffraction equation. We treat this as a probability function in our simulation. The equation takes into account the location of the double slit, as well as some properties of the particle, to find the probability distribution that a given particle can be present in the second metal sheet. An example of this function is shown in Fig. 1.

$$I(\theta)\alpha cos^2\left[\frac{\pi d sin\theta}{\lambda}\right] sinc^2\left[\frac{\pi b sin\theta}{\lambda}\right] \quad (1)$$

Equation (1): Fraunhofer diffraction equation. Note that near-field approximations are made when running through the code.

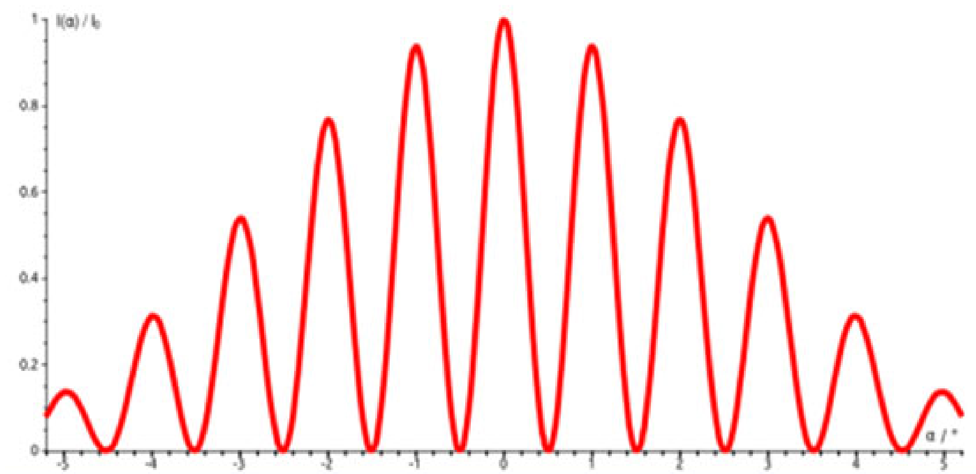

FIGURE 1. Intensity pattern (likelihood function) for a two-slit experiment from the Fraunhofer diffraction equation.

Modeling

First, we need to code the Fraunhofer diffraction equation so that we can calculate the probability of finding a particle at a given location.

Then we write a function to perform Monte Carlo against our likelihood function. First, we select a random location on the second view screen of the metal layer. We then find the probability that the particle is present at that location by calculating our diffraction equation at that location. Finally, we check the random number against our probability, and if our probability at that location is higher than the random number, we accept that location and say that the particle is present there.

This Monte Carlo roll probably samples our probability function to estimate the behavior of the probabilistic system. Each roll represents a possible particle that passes through the slits and appears at a certain location on the viewing screen.

With our likelihood function and Monte Carlo role, we can now run the simulation by continuously moving and recording the results. We are using the possible set of experimental parameters, but these can be changed (if we do, the above

After running our simulation, we can run the following code snippet to see the results shown in Fig. 2 and compare them to the actual interference pattern in Fig. 3.

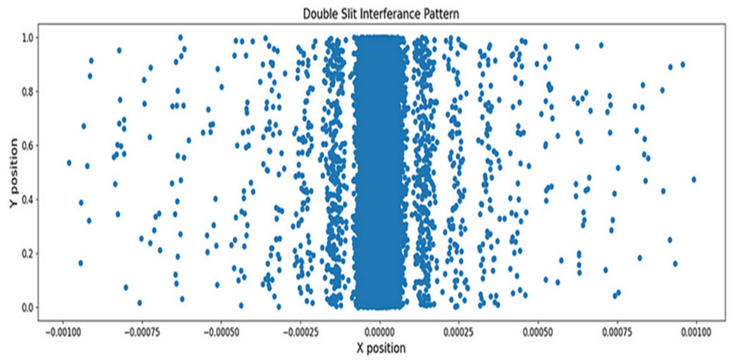

FIGURE 2. Simulated interference pattern.

FIGURE 3. Actual interference pattern.

It looks like a real interference pattern! The intensity, or clustering, of the dots in our simulation is consistent with what we would observe if we performed a two-slit experiment. As a further check on our results, we can compare our point distribution with the theoretical probability (Fig. 4.). We should expect our simulated distribution to follow the theory because we already knew and used the theoretical distribution.

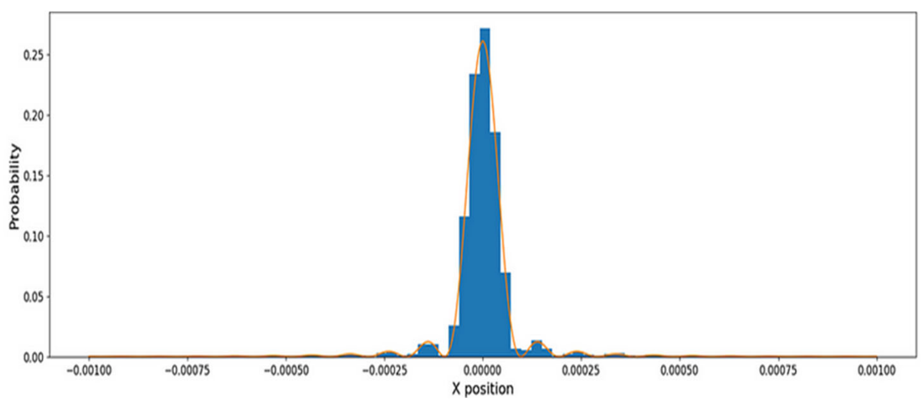

FIGURE 4. Theoretical probability versus simulated distribution.

It should be noted that in a wider range of cases outside the scope of this article, we may not have a probability distribution to work with, and this makes Monte Carlo methods very powerful. Even with unknown or partially known probability distributions, Monte Carlo methods can be used for modeling and sampling because they only need one criterion for testing. This criterion can be based on real data or in situ when it is not possible to map the entire probability distribution.

CONCLUSION

These software tools greatly assist students in learning physics and provide an opportunity to learn them in an interactive way. These methods help to increase students' interest in science and increase their understanding of science. All kinds of software learning tools make learning more convenient, taking into account the interests of students, and accelerate learning for students. Organization of educational processes through each program serves to establish creative communication between students and teachers and to evaluate the effectiveness of the program. The effectiveness of digital educational tools in the process of learning physics is that, along with improving students' knowledge, they have the opportunity to improve their skills by exchanging knowledge with other countries of the world. Digital learning technologies provide students with interactive, easy and convenient learning opportunities. These technologies play an important role in increasing the motivation of students and making the learning process simple and interesting. The rational use of the above-mentioned programs allows the students to put into practice, test and strengthen the theoretical knowledge they have acquired during the course of the lesson, and to create new ideas and find solutions to the created problems. It also creates an effective and useful learning environment for teachers and students.

In recent years, the use of computer programs in solving physics problems has become more and more common. These programs offer a range of techniques for solving complex equations and analyzing data, providing students and researchers with valuable tools for their work. One such method is Monte Carlo simulation, which uses random numbers to model the behavior of a system. By generating thousands or even millions of random samples, this method provides accurate estimation of various physical phenomena. In addition, numerical integration methods can be used to solve differential equations that cannot be solved analytically. These methods, among others, demonstrate the versatility and practicality of computer programs in solving physics problems. In this article, we have reviewed some basic theories of quantum mechanics and the double-slit experiment. In addition, we looked at Monte Carlo methods and how they can be used to simulate quantum systems. Although our simulation is simple, it demonstrates all the tools needed to dive deeper into quantum simulations; we will do that in the next articles.

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