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REVIEW ARTICLE

ROLE OF COMPUTERS IN PHYSICS EDUCATION – A REVIEW

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ABSTRACT

Physics is said to be difficult subject. Physics learning is not an easy task. There is strong evidence all over the world that physics students are not learning the concepts necessary for a good understanding of the physics world. Their learning of scientific facts remains in the classroom only. The computer is one of the most brilliant gifts of science having characteristics of speed, accuracy, reliability and integrity. It can execute over a million instructions per second without any mistake. It can carry our calculation in just a few minutes that would require month If carried out manually. The computational techniques have provided a friend and servant to science, technology and industry. In the present learning process computers are being used for enhancing physics learning also. They can be used to analyze and visualize data, communicate results, run experiment and monitor equipment. Computing can play an important and varied role in advancing physics learning. We point out role of computational techniques namely Simulations, Multimedia, Virtual Reality, Telematics and computer based labs which may deal with those difficulties and increase the learning process. Some good computer programs for learning physics exist. Emergent computational tools and new development in learning theories have contributed to change in education. But we are still in the middle of change process. The main objective of this paper is to discuss role of computer to understand physics and strengthen science and technology.

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INTRODUCTION

Physics is said to be a difficult subject. Among the reason for the learner's difficulties, one has been subject to intense research. Computer has become an inevitable part in physics education, for understanding concepts in physics and making the learning process interesting. In the present learning process computers are being used as naturally and normally as breathing. So their use has to be incorporated for enhancing physics learning also. They can be used to analyze and visualize data, communicate results, run experiments and monitor equipments. Computing can play an important and varied role in advancing physics learning. We point out the role of computational techniques namely Simulation, Multimedia, Telematics, Virtual Reality and Computer based labs which may deal with difficulties and increase the learning process.

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Computer Simulation Technique

Using computer simulation technique a student of physics can analyze, how far succeeded in approaching the actual result while doing an experiment in laboratory. Modeling is closer to laboratory experiments and is more likely to provide the student with a novel perspective on the behavior of a system. The fact is that once we succeed with the program, we can arrive at the most accurate results using it and can try with different cases of the same problem, without being restricted by so many limitations we usually face in the laboratory. Also it opens up a world of new understanding as we are now able to read any real life parameter, understand it and experience how they change with various activities we can try to understand the data, try to compare and contrast with the similar data. Multimedia: Multimedia is the exciting combination of computer hardware and software to develop effective presentations on an affordable desktop computer. The word multimedia means that modules include a variety of elements, such as texts, images, animations, simulations and video clips. Essential features of multimedia are interactivity and flexibility i.e. possibility of entering commands and ability to choose a path within the provided information. These factors

are required for good learning, the educational advantages of multimedia have been widely advocated .A nice example of use of multimedia in physics is the CD-ROM cartoon guide to physics. This disk may be used in physics classes although it is more recommended for extra class activities. Like other multimedia products created for science learning, it includes several interactive simulations. Specific uses of multimedia include the development of writing skills, problem solving, understanding science concepts, simulation and manipulation of data. Various multimedia tools are MS PowerPoint, Astound graphics, flash slideshow software, macromedia, windows, moviemakers and adobe acrobat reader. These tools make the system slide based, icon based, movie based and book based respectively.

Virtual Reality

With virtual reality the focus of learning is placed in the conception of environments that allows the student to interact with the computer with restrictions. A good learning environment requires free contact between the user and the computer. The main characteristics offered by virtual reality to education are immersion, interactivity and manipulation. Virtual reality brings together a set of characteristics that make it a unique technology as learning means:

- Virtual reality is a powerful visualization tool to handle 3D problematic situation
- Virtual reality can collect and show complex data in real time.
- Virtual environment allows learning situation by trial and error to explore a wide choice of possible solution
- The student is free to interact directly with the virtual objects, allowing first hand formulation and verification of hypothesis. The "SCIENCE SPACE PROJECT "is a good example of the application of virtual reality in education .It consists of series of virtual worlds designed to aid students in mastering challenging concepts in science.

Telematics

The Internet, the network of all networks has a big success in the society in general. Internet, the ultimate forest of computers is the house of loads of precious data of information. From the human genome database to lyrics of songs, internet is the most valuable resource. It has no limitations and free online encyclopedia like Wikipedia are world renowned for its authenticity and valuable information about anything and everything. It is now possible to find answers to any question, it is possible to see the pictures of universe taken by Hubble Telescope all we need to do is just to use some search engines such as GOOGLE etc. We can access loads of valuable scholarly papers, which were otherwise impossible to access. Loads of open courseware has made it possible to obtain knowledge for free! The most precious being the MIT OPENCOURSEWARE which offers courses of 400 different genres from engineering to basic sciences all for free! Internet is changing our teaching and learning styles. A good example of internet use for teaching physics is the JAVA based General physics course in USA e.g. "Mechanics" module is not designed to teach everything about mechanics. Instead the module is meant to be a guided tour through some concepts of mechanics and related mathematical techniques namely vectors, matrices and set of linear equations. The module offers opportunities to learn about mechanical and mathematical details in mechanical models. On the other hand "differential equations and mechanical oscillator" module is directed towards the study of mechanical oscillator. The first approach is analytical and conceptual. Assumptions are used to reduce the actual physical systems to a simple model. Then application of laws of physics leads to a mathematical model which consists of a system of one or more differential equations taken together with initial conditions.

The oscillator module is divided into three parts. The first is devoted to an in-depth treatment of mass attached to a vertically hung elastic spring, the second concentrates on the motion of a simple pendulum and third treats a spring pendulum system in which rod of simple pendulum is replaced by an elastic spring. VRML offers another possibility of using the internet. It extends the usual HTML interface with the ability to visualize 3-dimensional scenarios and interacts with their basic elements. In areas like molecular science and solid state physics, where the models need 3D representations, the new technique can be applied very effectively to improve understanding.

Computer based labs

Physics is an experimental science and the computer found already a place in the physics laboratory. The richness of computer based labs and associated modeling tools could have a major impact on physics teaching and learning. We can use them to place more emphasis on intuition and at the same time to give students the ability to solve complex problems. Much of what is wrong with science education is that students usually only learn about science, they do not participate in a meaningful way. Students at every level should have an Opportunity do real physics experiments to participate fully in learning new facts about the natural world. Hands on participation provide not only a strong motivation but more important is accurate understanding of science, whether their careers will lead them into physics or not. Learner controlled explorations in physics lab with real time measurements give students immediate feedback by presenting data graphically in a manner they can understand using sensors and software, students can simultaneously measure and graph physical quantities such as position, velocity, acceleration, force, temperature etc. The ease of data collection and presentation encourages students to become participants in a process which leads them to ask and answer their own questions. The real time graphical display of actual physics measurements directly couples symbolic representation with the corresponding physical phenomenon. Moreover, the comparison of a real data with simulation is very rich in pedagogical tool.

Some Examples

Amplitute modulation: Basic theory and equations behind amplitude modulation are relatively straight forward and can be handled using geometric calculations and manipulation, but an average student may not be able to grasp the idea

completely using spreadsheet. We can have a pictorial representation of what is happening.

Linear harmonic oscillator

The Eigen values and Eigen functions obtained by solving Schrödinger's equation is pretty involved and difficult for undergraduate students. Many questions of this problem can be answered by computational method used for solving second order differential equation is Range kutta fourth order method using Microsoft Excel. The animated wave functions speak volume about the characteristics of Eigen function. The discretization of Eigen values is also meaningful with the animation. And, comparison with the classical oscillator pictorially is satisfying. The correspondence principle for large quantum number becomes visual.

Modern physics phenomena

Three Phenomena photoelectric effect, Compton effect and pair production are studied using computer based on their governing equations, programs in C language are written to calculate the unknown quantity if the values of remaining quantities are given. In addition calculations are done by writing equations and graphs are plotted using MS Excel spreadsheets also. The computer programs help to evaluate the important parameter by bypassing the labor and drudgery of mathematical calculations. In addition they bring our some distinguishing feature of three phenomena e.g. unique frequency and energy range of each. They enable students to get familiar with very big and small quantities by their repeated use, to learn special instructions in C to handle them, to concentrate attention on the underlying physical processes of each phenomenon and thus enhance the learning physics.

Debye theory of specific heat of solids

The variation of specific heat of solids with temperature has been analyzed graphically using computational methods. The Debye theory of specific heat has been used to computationally differentiate between the essential differences between the specific heat of different solids. It has been demonstrated that the Debye temperature of solids play a crucial role in the specific heat profiles of the solids.

Numerical analysis of physics problem

Work done by a spring force is analyzed numerically with the help of Skylab which is open source software for numerical mathematics and scientific visualization. The results are compared with that obtained using C- program and always by analytical method and there is good agreement between them. Some important physics problems are also analyzed numerically using Skylab.

Conclusion

After briefly referring to the conception difficulties in learning physics, we have focused on the role of computer technologies to deal with them. We have classified the different uses of computers in physics; telematics, virtual reality and computer based labs seem to be more promising fields. They need to be further and better explored. Although, the computer has revolutionized the way we do physics, No computer can replace the teacher but it can surely replace the gap in understanding the concepts taught by a teacher.

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