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Teaching Methodology of the "Solar Energy" Course through Educational Software and its Impact on the Quality of Education

Alibek Hamrayevich Qodirov
Urgench State University named after Abu Rayhon Beruni

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Abstract: This article presents a comprehensive methodology for teaching the subject "Solar Energy" using modern software tools. The educational process consists of three main stages: delivering theoretical knowledge through lectures, reinforcing learning via tests during practical sessions, and studying the volt-ampere and volt-watt characteristics of solar cells through virtual simulations in laboratory work. This approach enables students to gain in-depth knowledge and practical skills in the subject and contributes to improving the quality of education.

Keys words: solar energy, software, lecture sessions, tests, practical tasks, virtual laboratory, volt-ampere characteristic, volt-watt characteristic, simulation, quality of education.

Introduction: In the Decree of the President of the Republic of Uzbekistan *"On the Approval of the Concept for the Development of the Higher Education System until 2030"*, a number of specific directions have been defined to ensure systematic reform, to identify priority areas of development, and to qualitatively elevate the process of training highly qualified personnel with modern knowledge, strong moral and ethical values, and independent thinking. The decree also sets goals to modernize higher education and to promote the development of social sectors and economic industries based on advanced educational technologies [1].

In modern education, the use of innovative technologies in teaching energy-related subjects, including solar energy, is gaining significant importance. Instead of traditional teaching methods, the use of interactive software tools, simulators, and virtual laboratories improves the effectiveness of the educational process. This article explores the methodology of using educational software in teaching the solar energy course and examines its impact on students' knowledge levels [2].

Main Body: When teaching the subject of solar energy, it is essential to provide students with both theoretical and practical knowledge about solar panels, inverters, batteries, and other equipment. In traditional classrooms, demonstrating all of these devices depends heavily on the availability of material and technical resources. Therefore, virtual laboratories and software-based simulators simplify the teaching process and create an interactive learning environment.

1. Lecture Sessions

In lecture sessions, theoretical information is provided about solar energy, its basic concepts and indicators, the operating principles of solar panels, the photoelectric effect, and the structure and types of solar cells (Figure 1).

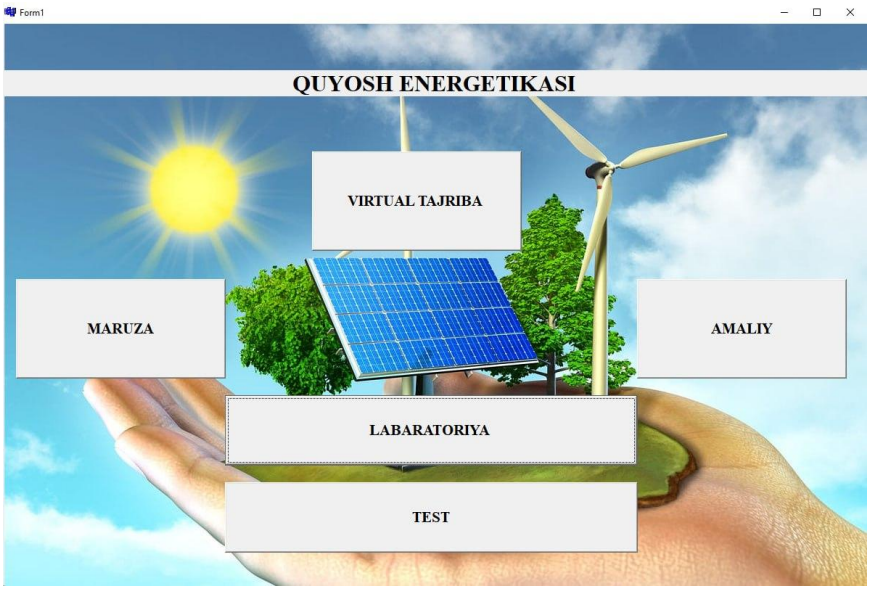

Figure 1. Simulation model of the knowledge consolidation process based on lecture sessions.

At this stage, students use the following software tools:

1. **Phet Simulations.** This platform allows the visual study of the relationship between solar panels, light energy, and electrical energy. It helps students understand the photoelectric effect.
2. **SolarEdge Designer.** An online platform that serves to design, optimize, and plan solar power stations. It allows the placement of solar panels in real-world settings, considering the impact of Earth's movements and provides an estimate of electrical energy production.
3. **PV*Sol Software.** This software is a professional tool designed to model the design and efficiency of solar photovoltaic systems. It enables the simulation of the operation of solar panels, inverters, batteries, and other components [3].

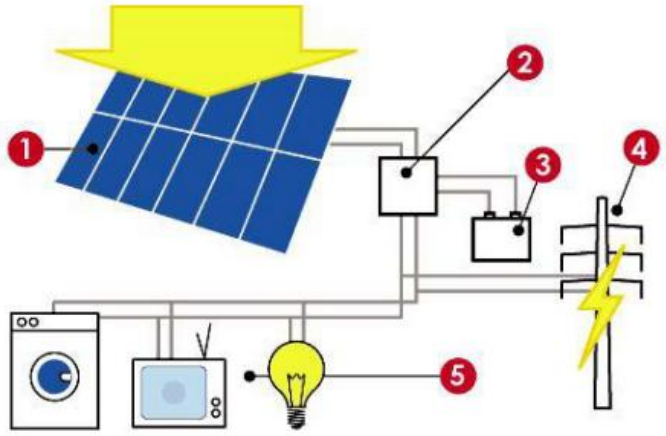

Figure 2. Simulation showing the operating principle of a solar panel

1 – Solar panel; 2 – Inverter; 3 – Battery; 4 – Electrical grid; 5 – Load

Dual Education Integration: In the dual education model, students spend part of the week at higher education institutions and the remaining part at production enterprises. Teaching the solar energy course using virtual laboratories simplifies the integration between these two environments. For instance, students strengthen their theoretical knowledge in a software environment before working with real objects.

2. Reinforcing Knowledge through Tests and Assignments in Practical Sessions

This simulation model is based on modern educational technologies and aims to strengthen students' theoretical knowledge during practical sessions through tests and assignments. Through this model, students test their knowledge in virtual environments, work on errors, and develop independent thinking skills. [3]

The main advantage of the model is the monitoring of the educational process through tests and assignments, providing an individual approach, and ensuring a deeper understanding of the taught topic. Additionally, the use of simulation ensures active student participation and the opportunity to consolidate knowledge for the long term (Figure 3).

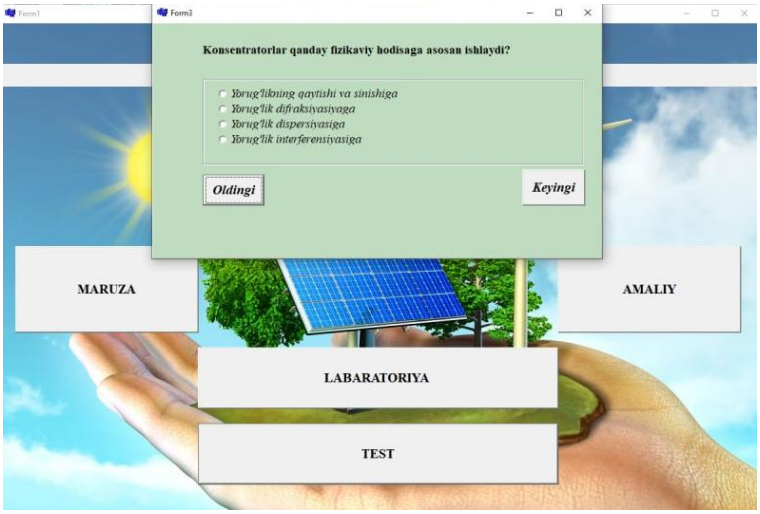

Figure 3. Simulation model of the knowledge consolidation process based on tests and assignments in practical sessions.

3. Studying Laboratory Exercises Based on Virtual Simulations Laboratory Topic:

Studying the Volt-Ampere and Volt-Watt Characteristics of a Solar Cell.

Solar cells (photovoltaic cells) are semiconductor devices that directly convert light energy into electrical energy. In this laboratory exercise, students will study the following characteristics of solar cells in a virtual environment. These processes are observed through a simulator (Figure 4).

1. **Volt-Ampere (V-A) characteristic** – the relationship between voltage and current.
2. **Volt-Watt (V-P) characteristic** – the relationship between voltage and the power produced.

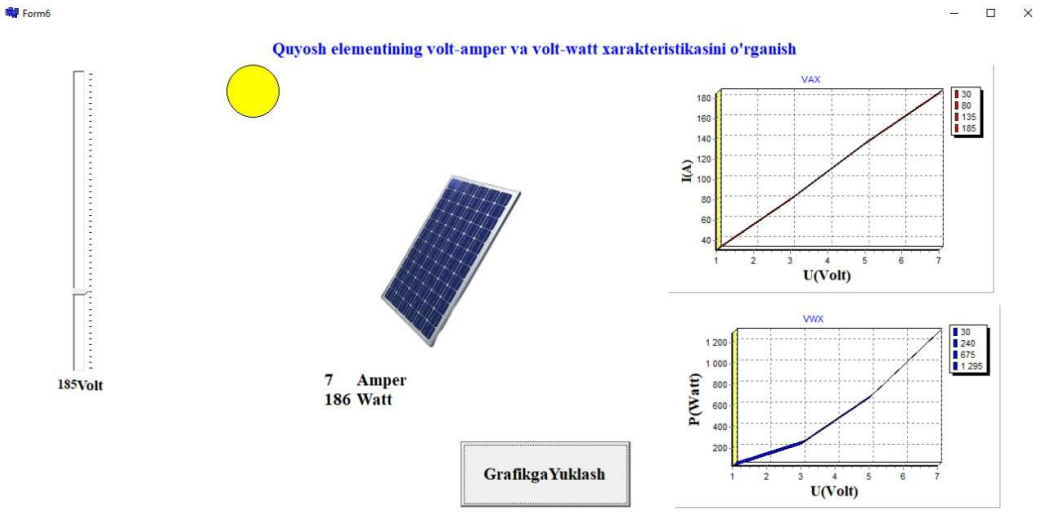

Figure 4. Simulation model of the Volt-Ampere and Volt-Watt characteristic processes.

Through the study of Volt-Ampere and Volt-Watt characteristics, the performance of the solar cell, its Maximum Power Point (MPP), efficiency, and sensitivity to illumination intensity are determined. In practice, this information is crucial for the optimal operation of solar panels and the effective design of energy systems [4].

Experiment Results: Experimental test lessons were conducted with 3rd-year students from the Electrical Energy department of Urgench State University named after Abu Rayhon Beruni. In the experimental group, the course was taught using educational software, while the control group was taught using traditional methods. The following table shows the changes in the knowledge levels of students in both groups:

Table 1.

Group	Initial Average Score	Final Average Score	Growth Percentage
Experimental Group	68.5	86.3	25.9%
Control Group	69.2	75.4	8.9%

As seen from the table, students taught through educational software achieved an average growth of 25.9%, while the group taught using traditional methods had a growth rate of 8.9%. This demonstrates the effectiveness of the innovative approach in the educational process.

Conclusion

The methodology of teaching the solar energy course through educational software significantly increases the effectiveness of the learning process. The results of the experiment showed that teaching through virtual laboratories and simulators not only strengthens theoretical knowledge but also yields high results in the development of practical skills. This methodology, especially when applied in the context of dual education systems, plays a crucial role in bringing the learning process closer to real-world production practices, developing professional competencies, and training competitive specialists for the labor market.

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