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Teaching Renewable Energy Sources Using 3D Virtual World Technology

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***Abstract*—Virtual Worlds open up new horizons for the learners that were not available before. In this paper, we present a 3D Virtual World developed to assist tutors in teaching and students in learning the domain of Renewable Energy Sources (RES). Several types of power plants and devices such as wind turbines, photovoltaic panels, hydropower turbines and geothermal ponds have been designed and programmed to simulate their operation in the real world. Virtual facilities like classrooms, labs and libraries were created to support training and learning and assist teachers in conducting their courses. The environment provides learners the ability to interact with the 3D objects and constructions, manipulate their parts with the aim to can get a deeper understanding of their functionality. The evaluation study conducted revealed quite satisfactory results.**

Keywords-component; 3D Virtual World; e-learning; Engineering Education; Teaching Renewable Energy; Opensimulator;

I. INTRODUCTION

Virtual worlds have rapidly become an important part of the educational technology landscape mainly due to the intrinsic characteristics of the 3D simulations [1]. Nowadays, researchers, tutors and educational institutes study and use 3D Virtual Worlds to assists not only students in learning but also tutors in teaching and managing courses to the best advantage of the students.

Over the last decade there have been a vast amount of works and research interest on the development of educational 3D virtual worlds to assist teaching various domains. A detailed overview of approaches and methodologies can be found in [7]. Virtual worlds have been developed and successfully used to help students learn a wide range of domains such as software engineering [12] logic programming [11], history and archeology [3][10], STEM (Science, Technology, Engineering, Mathematics) [5], chemistry [6], aerospace engineering [8] electricity and power transformers [2] .

The domain of power generation from renewable energy sources (RES) such as the wind, the sun, the water etc, is considered to be a difficult domain for tutors to teach and learners to understand. It is acknowledged by many engineering tutors that it is a hard domain that cannot be approached as a traditional engineering subject. Indeed, it consists of complex processes that traditional education fails to cover and efficiently teach.

In this paper, we present an educational platform developed based on 3D virtual worlds to assist tutors in teaching and students and professionals in learning the challenging domain of energy generation from renewable energy sources. Several types of power plants such as hydroelectric plants and constructions such as wind turbines, photovoltaic panels, hydropower turbines and geothermal ponds have been designed and programmed to simulate their operations in the physical/real world.

The rest of the paper is structured as follows: Section II presents the 3D virtual world developed and analyses its main functionalities. Section III presents the evaluation study conducted and the results extracted. Finally, Section IV concludes the paper and provides directions for future work.

II. 3D VIRTUAL WORLD

The 3D Virtual World (VW) developed is implemented in the OpenSim [9], an open source multi-platform, multi-user 3D application server. In the VW, users are represented as avatars and can move within the world, visit constructions (such as factories, plants etc.) examine 3D objects and interact with them, study educational materials and take exercises and quizzes. Tutor-avatars can organize virtual classes in a synchronous or asynchronous way. The use of an avatar in the VW provides a sense of presence and awareness and enhances the ability to interact with the 3D constructions in the world and also communicate and collaborate with the other students and the tutor [4].

In the VW, several plants and big constructions were developed with the aim to simulate those of the real world. The learner has the ability to visit specific plants such as hydroelectric plants and see how they operate. In addition to the plants, specific 3D objects were developed to demonstrate the operation of real world machines and devices. The learners can examine how 3D objects such

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as different types of wind turbines or solar panels are constructed and operate. In Figure 1, a 3D object that represents a wind turbine is presented.

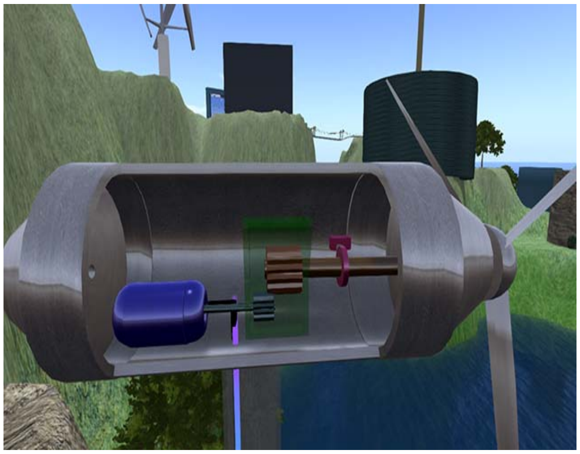

Figure 1. A wind turbine in the 3D virtual world

They can also interact with each object by clicking on it and manipulate specific parts of it with the aim to get a deeper understanding of their operational procedures. OpenSim allows giving physical characteristics to 3D objects (e.g. mass and elasticity) as well as adding scripts (LSL language) that give them behaviour such as animating, rotating and simulating specific sub-processes. Scripts also allow interacting with the users through messages, dialogs and sounds. Many of the objects in the virtual world utilize such scripts to make the user's experience more interactive and natural. For example the learner can click on various parts of a device to get a description and take part in interactive exercises by manipulating 3D items. Scripts were also very useful to make the 3D world more interactive, "alive" and physical.

The virtual classrooms can support tutors' lectures to groups of students and simulate at some degree the physical classrooms in a real school. The tutors can schedule a lecture at a specific room of the virtual world to take place at a specific time and date. The students and the tutors can have a common place to meet and communicate regardless of their physical locations. Furthermore, the developed Virtual Library, contains all text material regarding the RES domain. The educational materials are presented as books and are organized in selves (Figure 2). The student can select a book by clicking on it, in order to open it and study corresponding theory in text format on the corresponding presentation screens.

For each learning topic the student will find various types of learning materials that complement each other. For example, to study about how photovoltaic cells produce energy, in the virtual world, one can look at text-based presentations that cover theoretical aspects and also explore corresponding 3D objects.

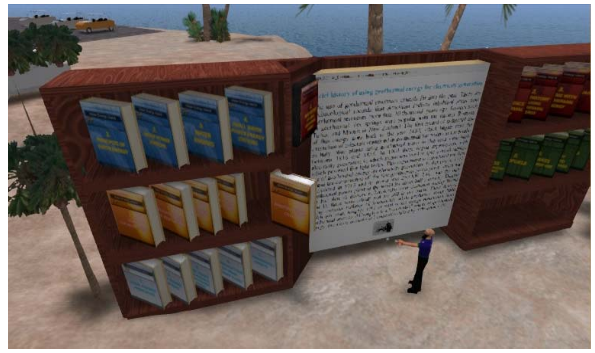

Figure 2. The virtual library

For example, a 3D object represents the layers of a photovoltaic (PV) cell with particles visualizing procedures like the release of electrons (Figure 3). By clicking on each different layer, a dialog message will appear describing the layers characteristics, functionality and animating its part in the process.

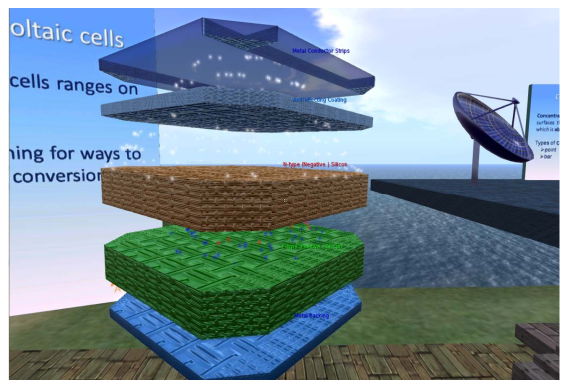

Figure 3. An interactive 3D object

III. Evaluation

We have used a quantitative method to investigate the effect of the 3D Virtual World. The purpose of the study was to examine the effectiveness of the VW against the classroom learning way. This study's participants were 80 students (male and female) enrolled in the RES Course. All participants were vocational school students in the 2nd and 3th year of study and their age ranged from 15 to 17 years. In order to evaluate the learning effectiveness on the students, we used a pre-test and a post-test approach. The students were divided into two groups of 40 students each. Then, one group was randomly selected to serve as the experimental group, while the other served as the control group. The control group was selected to study through traditional way and the experimental group to learn through the 3D Virtual World. Initially, all students took a pre-test on RES concepts. After that, the students of experimental group, which were selected to use the 3D Virtual World, were given access to it. We analyzed experimental data using the statistical package SPSS v21. As presented in Table I, the mean value and standard deviation of the pre-test were 11.275 and 17.525 for the experimental group and 11.425 and 15.375 for the control group respectively.

TABLE I. DESCRIPTIVE STATISTICS OF PRE-TEST AND POST-TEST

	Group	N	Mean	Std. Deviation	Std.Error Mean
pretest	Control	20	11.425	1.6325	0.3650
	Experimental	20	11.275	1.6896	0.3778
posttest	Control	20	15.375	1.6849	0.3768
	Experimental	20	17.525	1.3810	0.3088

The results show that the experimental group learned better the RES course than the control group. Most of the participants agreed that the VW is easy to use (70%), and they enjoy learning (85%) in the VW. Most of the students stated that the VW can enhance their engagement in the course (68.5%), their learning interest (72.5%) and motivation (60%). What is more, 87.5 of the students denoted that the VW makes the course more understandable (87.5%), helps them learn more effectively (85%) and the 3D objects enriched their knowledge (75%) and helped them better understand their operational processes (90%). Finally, the majority of participants would suggest next year students to use the VW.

IV. CONCLUSIONS

Virtual Worlds open up new horizons for the learners that were not available before. In this paper we present an educational platform developed based on 3D virtual worlds to assist tutors in teaching and students in learning the domain of energy production from renewable sources. The evaluation study conducted revealed very encouraging results. The virtual world has been shown to attract student's interest, while 3D interactive objects provide a great way to see how each device works and what parts it consists of, thus making learning more attractive and effective.

However there are some points for future work. Initially, a bigger and more detailed scale evaluation will provide a deeper insight of the platform’s teaching effectiveness and its capabilities. Furthermore, we plan to develop embodied virtual agents to accompany learners and offer personalized guidance and assistance. Another direction for future work concerns the development of a mechanism responsible to record and analyze the actions and the behaviour of the students in the virtual world with the aim to get a deeper understanding of the student and better adapt learning to each student’s background and needs. Exploring this direction is a key aspect of our future work.

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