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Examining the Impact of Pedagogical Agents on Students Learning Experience in Virtual Worlds

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Abstract

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***Abstract*—Virtual worlds constitute an important part of the educational landscape that possesses unique learning capabilities and opens up new horizons in education. A vital part of 3D virtual worlds concerns the intelligent pedagogical agents that are integrated in the environments and aim to improve the interaction with the users and enhance their learning experience. The main purpose of this study is to assess the impact that the pedagogical agents have on students' engagement and learning experiences during training activities in virtual worlds. Specifically, we examine how students perceive the role of pedagogical agents as learning companions during specific exercises and activities and the impact that the guidance offered via pedagogical agents has on students' engagement and learning. In this regard, an experimental evaluation study was designed and performed in a 3D virtual world educational environment that is used to assist students in learning aspects of environmental engineering. The results of the study show that the assistance and the help offered to students via pedagogical agents have great impact on students' engagement and improved their learning experiences.**

Keywords—pedagogical agents, virtual worlds, engagement, learning experience

I. INTRODUCTION

Over the last years, the constant technological advances have offered to education new innovative tools and approaches that are more attractive to learners and can support more efficient learning procedures. Virtual Reality constitutes an important technology in the educational landscape, which can be used in different levels of education and in various domains, with the aim to assist students in learning and building their knowledge in innovative and more attractive ways. 3D virtual world educational environments have the ability to offer learners a broad range of learning activities and procedures and have been integrated in various challenging domains and topics [1][8]. Educational systems that are based on virtual reality and 3D virtual worlds can assist both teachers in their teaching procedures and learners in their knowledge construction and comprehension [10][12][19]. In addition, they have the ability to improve students' learning experience as well as the effectiveness and the learning impact of the training processes [5][6][9].

An important aspect of the 3D virtual world educational environments concerns the social and personal affordances that users experience. It is widely acknowledged that a main issue of e-learning systems relates to the lack of efficient social and personal presence [15][21]. In this regard, intelligent pedagogical agents can be designed and integrated in virtual world educational environments with the aim to improve the interaction with the students and better support them. In 3D virtual worlds, pedagogical agents come as avatars and are embodied virtual characters that are employed to support learners and to serve various instructional goals [25]. The design and integration of intelligent pedagogical agents in 3D virtual learning environments can assist in improving the intelligence and the believability of the environment as well as the communication with the learners [2][17]. The main principle refers to the enrichment of the virtual learning environments with autonomous agents so as to support the learning process [23]. In this line, intelligent pedagogical agents can have a central role in virtual world environments as they can serve diverse instructional goals and have a wide range of tasks and functionalities [24]. Pedagogical agents can support students self-learning and try to simulate to some degree the role of the teacher. In addition, they can be utilized as learning companions to guide students in the virtual world and assist them during exercises and learning activities[25]. They also offer great promise for delivering sophisticated, real-time, problem-solving assistance, guidance with visual appeal and accompany learners in learning activities. In addition, they can offer and increase students' learning with the provision of customized feedback, and also further engage and motivate learners to interact more frequently with the learning activities [14]. The social presence they offer to students is crucial and several studies highlight that once learners realize that a social

interaction is taking place, they feel as though they have to employ human-human social interaction conditions and rules due to the fact that the software is perceived as a social partner [16][18][20].

Hence, the appropriate and efficient integration of pedagogical agents in the learning procedures is highly desirable. In this context, the aim of this work is to study the impact that the intelligent pedagogical agents have on students' engagement and learning experience during learning activities and assess their role as learning companions in virtual worlds. Specifically, we examine the impact that the assistance offered via pedagogical agents during exercises and gamified activities have on students' engagement and their learning experience. In this regard, an experimental study was designed and conducted in a 3D virtual world that is used to assist students in learning aspects of environmental engineering and renewable energy sources. Students have participated in various gamified learning activities in the 3D virtual world educational environment under different situations and contexts in terms of assistance and presence of pedagogical agents. The results indicate that the behavior, the presence and the interaction of the pedagogical agents can improve students' learning experience and also increase their engagement with the learning activities.

The reminder of the work is organized as follows: Section II describes the virtual world educational environment used in our study and presents its educational infrastructure, the learning activities designed and the functionality of the pedagogical agents integrated in the environment. Section III illustrates the experimental study performed, the results collected and the main findings of the study. Finally, Section IV presents conclusions and provides main directions that future work would examine.

II. The Virtual World Environment

In this section, we describe the 3D virtual world environment that was used in our study and analyze its educational infrastructure and its characteristics. Subsequently, we describe the intelligent pedagogical agents as designed and integrated into the virtual environment.

A. The 3D Virtual World Educational Environment

The 3D virtual world educational environment aims to assist both students in learning and teachers in conducting their courses on the domain of environmental engineering and energy generation. The virtual world was designed with the aim to resemble and replicate the real world context, so that the students can study in an educational environment which is close to reality.

In the 3D environment, various constructions, buildings and power plants were designed to resemble the respective constructions of the real world environment and also mimic and visualize their functionality. Learners can visit the constructions and the power plants and examine the way that they perform their procedures. What is more, the virtual world offers procedures that are based on constructionism approaches [13]. In this line, various parts and components of machineries can be combined and interlinked with one another in order to formulate more complex constructions. Learners can discern the parts from which each construction or machine is built and can examine the way it operates. In Fig. 1, a simple construction that is designed to simulate wind turbines is presented.

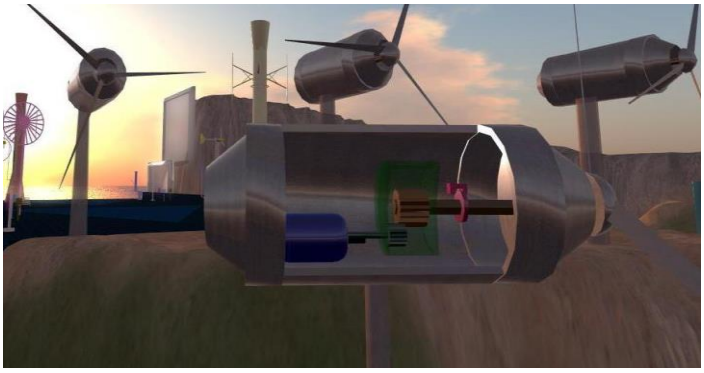

Fig. 1. Constructions in the 3D virtual world representing wind turbines

The 3D virtual world educational environment has been developed in the OpenSimulator platform and the 3D constructions were designed to have physical characteristics and natural behavior that resembles the real world. On the technical level, scripts written in the Linden Scripting Language (LSL) enable the educational infrastructures, constructions and objects to acquire specific behaviors, and simulating procedures so as to facilitate interaction with the students. The scripts can also make the 3D virtual world environment more vivid and real, allowing more natural interaction.

In the virtual environment, learners have the opportunity to interact with constructions by clicking on them and inspect their functionality and their operational characteristics. Different objects can be joined and formulate a global generic process together such as, for example, the transmission gears and the rotors of a wind turbine that simulate the operation of a real wind turbine. The virtual machines and constructions aim to support students in forming mental models of corresponding concepts by simulating and visualizing their operational behavior.

In the virtual world, students can find the courses and the specific learning topics of each one as well as a wide range of complimentary educational material in various formats. For instance, while students exploring the functionality of photovoltaic cells and their operations for the production of energy, they also have the opportunity to study, in the virtual world, the theoretical parts via text based presentations. In addition, they can examine the functionality of the corresponding 3D virtual constructions and machines. A 3D construction, illustrated in Fig. 2, depicts the main layers that

photovoltaic cells consist of, and visualizes the relevant phenomena and procedures.

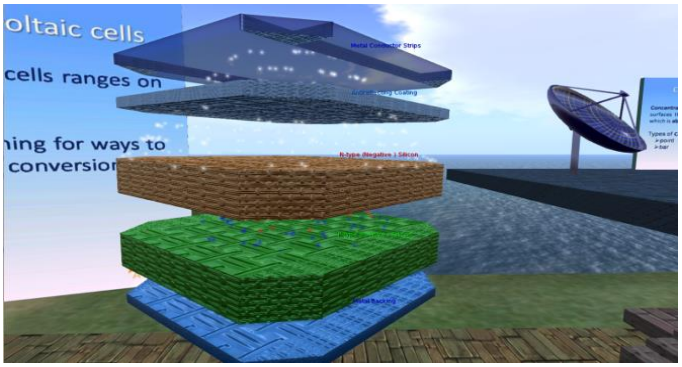

Fig. 2. Layers of photovoltaic panels in the environment

The student can interact with the 3D construction and by clicking on each different part. After that, specific visualizations and dialog messages appear, describing the characteristics of the specific part of the construction, analyzing its functionality and animating the specific processes that the part performs. In this spirit, theoretical and abstract concepts can be associated via the object animations with specific operations and concrete functionalities.

In addition to the 'hands-on' experience that students can have, a set of practical exercises, tests and quizzes is also provided to them with the aim to evaluate their knowledge and comprehension on various topics and procedures (see for instance Fig. 3).

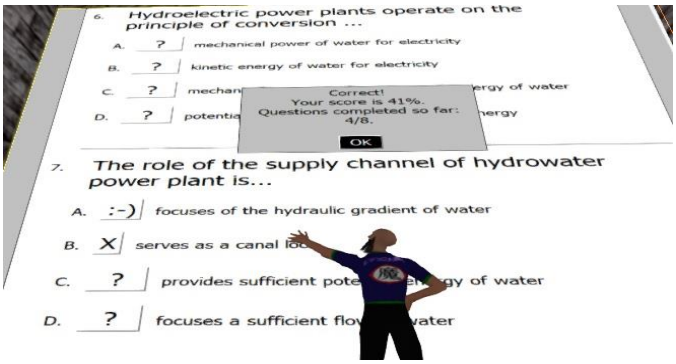

Fig. 3. Example of multiple choice exercise in the environment.

B. Learning approaches and activities

In the 3D virtual world educational environment, various learning activities were designed and offered to the students. The student can manipulate and interact with constructions in the context of gamification scenarios. For example, students can participate in training scenarios where electrical failures have occurred and have blacked out the energy production in a factory. Working as individuals or teams, students, are requested to trace the failure and make appropriate actions to fix it. To face the problem and complete the purpose of a training scenario (e.g. the blackout problem), students have to examine the power plants and constructions, trace the origin of the malfunction and make suitable actions to fix it. The solution may require to identify the faulty part of a machine and to replace it by determining appropriate item and part that have the necessary specifications. After the successful repair of the faulty object and the resolution of the problematic situation, rewards can be given to students who were able to accomplish the tasks.

Furthermore, in some training scenarios, students are given practice exercises, consisting of sets of questions to answer, that require that they visit factories and examine special procedures or devices and interact with them. The aim is to examine these procedures and interact with the devices in order to understand the way they operate and, after doing so, specify the answers to the questions. In the learning scenarios, students can take part as individuals or as teams, consisting of two or more students, and the activities assigned to them can support and enhance their communication and collaboration. Indeed, learning activities in virtual worlds can provide the means and conditions to stimulate and improve the collaboration and cooperation between the students and the pedagogical agents of the environment [11].

C. Pedagogical Agents

The pedagogical agents are designed and incorporated into the virtual world in order to accompany learners and support them during the training activities. The agents are avatars controlled exclusively by scripts and can guide students and provide context about their objectives during the activities. To some degree, they aim to simulate the role of an actual teacher who stands by the student, supervises their actions and assists them during their learning activities and exercises.

Fig. 4. An example agent in the virtual world.

Students, after having studied the theoretical content of a specific topic of the domain of the environmental engineering, can take exercises and participate in learning activities. The main purpose of the learning activities is to assist students in putting theoretical knowledge into practice. The students can interact with the agents in order to get exercises and learning activities as discussed above. After that, the learning activity starts and the agent accompanies the student during the activity. When in need, the student can request for assistance and the

agent can provide confirmations whether an answer is correct or not, address the answer and the related topics, specify particular error(s) and guide the student about what to do towards the correct answer [22]. Specifically, the assistance concerns hint messages of what to do first/next and hints to the relevant theory concepts involved in the activity. After the successful completion of an activity students can interact with the agent in order to get additional ones and proceed to the following activities. The learning activities are given to students in an incremental difficulty level approach starting from 'easy' and, as the student progress, more difficult and complex tasks are available and provided to them.

III. Experimental Study

An experimental study was performed to assess learners' experiences and evaluate the effect that the pedagogical agents had on their learning. The main purpose of the study was to evaluate the effectiveness of the pedagogical agents and the way that students perceived their assistance and their guidance in the 3D virtual world educational environment. For this purpose, an experiment was designed and implemented, in our university, in the context of a course. The study consisted of two different experimental context scenarios in the environment and examined students learning experience in both of them.

In the first context scenario, the pedagogical agents were in their full and complete functionality. More specifically, at the starting point of the learning activity, the pedagogical agent accompanied the student closely, walking side by side, thus, allowing the student to interact with him at any time and get assistance related to possible errors or guidance on how to proceed in the activity.

In the case of the second scenario, the pedagogical agent provided the student with learning activities and after that, the students were on their own to complete the learning activity. Nevertheless, students can again request for assistance and guidance, which appears via the instant messaging function and was provided as a message in the chat area. In either case, the content of the assistance was exact the same in both scenarios. However, in the second scenario, the agent was absent and the assistance message was displayed as a message in the chat area of the user in the environment.

A. Methods

In order to explore in greater detail the impact that the pedagogical agents have on students' engagement and their learning experience, an experimental study via the experimental/control group approach was designed and performed. In this context, forty-two (42) undergraduate students (both male and female), with prior experience in using 3D virtual world educational environments, were randomly selected and invited to participate in the experimental study. Participants were almost at the same age and at the same year of study. They were invited to participate in the experimental study in the context of their course and they were informed that all their info will be anonymous and that they will be used only for the purpose of the study. Students that participated in the study, were randomly separated into two groups, named Group A and Group B, and joined the virtual world. Group A, undertook the learning activities in accordance to the first scenario, whilst, Group B, the second. In Fig. 5, the design of the experimental study is presented among with the way it was conducted.

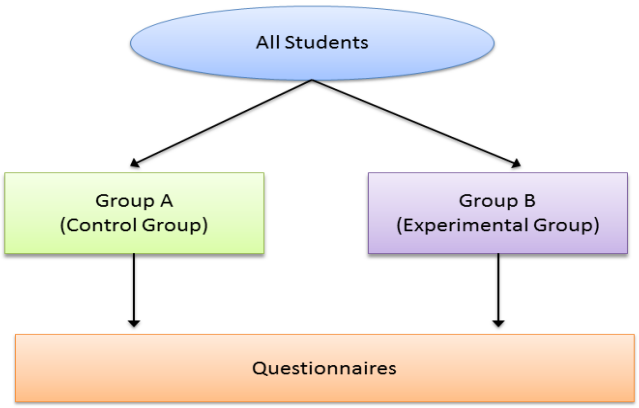

Fig. 5. The main parts of the study.

Students, after creating their personal account, were given a two-week window to study in the environment the subject under investigation and prepare for the actual exercise. Upon the completion of the experiment of the two weeks, participants were requested to fill in two questionnaires, a Likert-scale survey and the System Usability Scale (SUS) questionnaire [4]. The aim of these instruments was to evaluate students' attitude towards the virtual environment and assess their learning experience.

1) Likert Scale Questionnaire: The first questionnaire was a five-point Likert scale survey whichaimed at enabling students to express their agreement to a set of statements. The questionnaire included 10 questions of which 8 were based on Likert scale (1: not at all, 5: very much), and two were open-ended. The questions and the results are presented in Table I and II respectively.

2) System Usability Scale (SUS): The second questionnaire [4] was used for assessing the usability of the environment. The main reasons for which we opted in for utilising this SUS was its short length, as it is comprised of ten (10) items,and ease to answer. The items are divided in two equispaced categories (positive and negative) and are to be rated on a five point scale (strongly agree to strongly agree). The overall SUS score is a single number in the range from 0 to 100 and the output result is easily comprehensible. In addition, the SUS questionnaire consitutes a robust mean for measuring the system usability, even with a small sample sizes. Regarding the overall SUS score, a score over 85 indicates that thesystem is highly usable, whilst a score from 70 to 85 is considered to be good to excelent. A score in the range of 50 to 70 indicates that the system is acceptable but in need of improvements (interaction, usability), and, finally, a score below 50 is characterized as unacceptable [3].

B. Results

The first part of the discussion concerns the analyses of the Likert questionnaires and the estimation of their reliability. In this line, for assessing the reliability of the questionnaires and securely analyzing the collected data, Cronbach's alpha metric [7] was used. Cronbach's alpha in our questionnaires was calculated to be 0.77 and 0.79 respectively. This indicates that the reliability of the questionnaires is rated as 'good' and thus, we can draw strong, reliable and valid conclusions. The analyses of the questionnaires of both groups are presented in the following tables.

TABLE I. GROUP A QUESTIONNAIRE RESULTS

Q	Questions	Answers (%)				
		1	***2***	***3***	***4***	***5***
1	I enjoyed using the 3D virtual reality environment	0.0	0.0	9.5	9.5	81.0
2	The assistance during the learning activities was helpful and assisted me.	0.0	0.0	4.8	9.5	85.7
3	I feel comfortable and confident during the learning activities.	0.0	0.0	4.8	14.3	81.0
4	The learning activities made me more active in the activities.	0.0	0.0	4.8	14.3	81.0
5	The learning activities can increase my motivation.	0.0	0.0	4.8	19.0	76.2
6	The learning activities can enhance my engagement.	0.0	0.0	4.8	9.5	85.7
7	The learning activities can enhance my interest.	0.0	0.0	9.5	9.5	81.0
8	I recommend the 3D virtual reality environment to other classmates and be integrated in the course curriculum.	0.0	0.0	4.8	4.8	90.5

TABLE II. GROUP B QUESTIONNAIRE RESULTS

Q	Questions	Answers (%)				
		1	***2***	***3***	***4***	***5***
1	I enjoyed using the 3D virtual reality environment	0.0	0.0	9.5	14.3	76.2
2	The assistance during the learning activities was helpful and assisted me.	0.0	4.8	14.3	14.3	66.7
3	I feel comfortable and confident during the learning activities.	4.8	9.5	4.8	14.3	66.7
4	The learning activities made me more active in the activities.	0.0	4.8	9.5	14.3	71.4
5	The learning activities can increase my motivation.	0.0	4.8	9.5	14.3	71.4
6	The learning activities can enhance my engagement.	0.0	4.8	9.5	9.5	76.2
7	The learning activities can enhance my learning interest.	0.0	4.8	4.8	19.0	71.4
8	I recommend the 3D virtual reality environment to other classmates and be integrated in the course curriculum.	0.0	0.0	4.8	14.3	81.0

The analysis of students' answers on the questionnaires shows that students of Group A, who had the assistance of the pedagogical agents during the learning activities, had a better learning experience in the virtual world educational environment. Specifically, of the majority of students in Group A enjoyed more their interaction with the virtual world educational environments and maintained a better attitude towards the learning activities. Indeed, the results point out that a bigger portion of students of Group A found the learning activities to be more attractive thus, increasing their interest, motivation (76.2 % vs. 71.4 %) and engagement with the subject (85.7% vs. 76.2%). Furthermore, students of Group A indicated that they felt more comfortable and confident during the learning activities (81.0 % vs. 66.7%).

Regarding the analysis of the SUS questionnaires that students filled in, the results were very indicative about the usability and the attitude that students had towards the overall usability of the environment. Specifically, the SUS score of the questionnaires of Group A was calculated to be 78 while the SUS score of the students of Group B was 71. The results indicate that the students of Group A had a better experience in the environment as far as their interaction with the environment is concerned. The results of both the questionnaire studies highlight the importance of the pedagogical agents as learning companions and their assistance in students learning.

IV. CONCLUSIONS

Intelligent pedagogical agents constitute an important part of virtual reality learning environments. In this work, we study the impact that the pedagogical agents have on students' engagement and learning experience during learning activities and we assess their role as learning companions in virtual worlds. Specifically, we examine the impact that the assistance and the guidance offered during exercises and gamified activities have on students' engagement in the exercises and their learning. In this regard, an experimental study was designed and conducted in a 3D virtual world that is designed and used to help students to study aspects of environmental engineering and renewable energy sources. Students have participated in various gamified learning activities in the 3D educational environment under different situations and contexts in terms of assistance and presence of intelligent pedagogical agents. The results indicate that the behavior, the presence and the interaction of pedagogical agents increase students' engagement and enhance their learning experiences.

There are many directions that could be examined as future work. First we plan to formulate more concrete and sophisticated feedback sequence strategies and examine their effect on students learning. Another direction for future work concerns the formulation of collaboration learning approaches where students can study and practice as groups of professionals, with the aim to examine and assess the impact of the intelligent agents on collaborative learning activities. Finally, the integration of learning analytics, as a mechanism to record and analyze students' actions in the virtual environment and exact behavior patterns, is another research avenue that we

will examine as it is expected to provide a deeper understanding of students learning construction and their experience. This direction constitutes an important aspect of our future work.

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