Artificial Intelligence in 3D Virtual Environments as Technological Support for Pedagogy

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Abstract. This paper researches the opportunities available to use 3D Virtual learning Environments (3D VLEs), such as Second Life, to create e-learning Project Innovation for students using 3D Virtual Design concepts and programming. This entails the use of programming and coding to create bots (artificial intelligence robotic avatars) that can be used to direct interactive teaching and learning activities inside a 3D VLE. Moreover, through the creation and coding of holographic platforms (holodecks) inside 3D VLEs, diverse classroom and environmental settings can be created to aid in the e-learning process and help the students themselves to use this technique to create immersive 3D projects e.g. 3D catalogues and exhibitions. This is in addition to the prospects of using these holodecks for educational role-play activities, modelling activities and interactive discussions and seminars.

Keywords. Artificial intelligence, E-Learning, Blended Learning, 3D Virtual Worlds, Teaching Learning Innovation, Second Life, Bots, Psychology

Introduction

3D Virtual Learning Environments (3DVLEs) have been a host for many virtual campuses of universities, e.g. Harvard and Cambridge, since their offset more than a decade ago [1]. These virtual media offer innovative opportunities for technologically supported pedagogy and e-learning for many fields of sciences and arts which has reaped noticeable participation, satisfaction and hence achievement from students [2]. Through 3D VLE online courses, online avatars allow students and their instructors to interact synchronously by audio, text chat and other media presentation techniques [3]. It thus becomes imperative to investigate the merits of migrating with delivery of e-learning to these environments.

The emergence of digitally influenced generations of students, whom Prensky [4] and Oblinger and Oblinger [5] referred to as "Digital Natives, "Games Generation" and "Millenials", deems it logical to anticipate why in order to enhance future learning, students are currently being encouraged to utilise game-like 3D virtual worlds, or VLEs like Second Life, Active Worlds and others to accommodate for new cognitive style changes. These play an essential role in shaping future e-learning as suggested by Wang et al. [6], specifically with the potential to bridge the gap between simple knowledge of a topic and hands-on experience with it i.e. "learning by doing" [7].

Furthermore, a paradigm shift in education also emerged called "Animated Pedagogical Agents [8]. This uses lifelike autonomous 3D characters or avatars that cohabitate the learning environment to provide a rich interactive face-to-face interface and activities with students who are also embodied in the learning environment as avatars [9]. These recently can be coded / programmed to provide an intelligent tutoring system as will be explained subsequently as part of the pedagogical practices presented in this research.

The previously described technological advances and practices support the developmental perspective of teaching and transmission of knowledge by adopting the constructivist paradigm/approach to teaching and learning. As indicated by Mikropoulos and Natsis [10] Constructivism seems to be the theoretical model the majority of the 3D VLEs are based on. This can be explained by Dalgarno's and Lee's [11] conception that "technologies themselves do not directly cause learning to occur but can afford certain tasks that themselves may result in learning". Thus examples of supporting the constructivist paradigm will be seen in the following sections that fulfil the seven principles of constructivism as presented by Jonassen [12]:

1. Provide multiple depictions of reality
2. Focus on knowledge construction not reproduction
3. Produce genuine tasks
4. Provide case-based learning environments
5. Promote reflective activities
6. Enable context and content dependent knowledge construction
7. Support collaborative negotiation

The teaching/learning examples adopted and suggested for creation in this research encourage, through project work, constructing new subjective knowledge in students that is influenced by their prior experiences. Hence the constructivist approach to teaching/learning rather than objectively and passively acquiring knowledge as is the case with behaviourism [13]. Students learn as they work to understand their experiences and create meaning from it. Therefore, teachers are facilitators who create a curriculum to support a self-directed, collaborative search for meanings [14]. In this case the curriculum would encompass programming and coding bots (artificial intelligence automated avatars) inside 3D VLEs to offer interactive activities for students. As a result since students have diverse perspectives, backgrounds, learning styles and experiences, this collaborative learning environment would provide an abundance of benefits [15]. This has the possibility of increasing even more with the technological capabilities suggested above. Additionally this aligns with the developmental perspective for teaching and learning which relies on encouraging self-exploration and inquiry, by "cultivating ways of thinking" beyond the tutor's supervision [16]. Hence, with the developmental perspective students are guided towards deriving problem solutions but not provided with them.

There is a challenge to integrate contributions from a number of different disciplines into a single learning support offering that will (i) take under consideration the pedagogic needs associated with the use of 3D VLEs, (ii) address usability and web 2.0 issues from the use of a social learning network and (iii) investigate 3D VLE interactions with the mediums used to access learning platforms. So far the creation of

intelligent 3D VLEs is primarily concerned with the design of content for virtual learning tasks.

The next section will demonstrate several educational scenarios through the creation and use of bots (artificial intelligence automated avatars) inside Second Life, an example of 3D Virtual Learning Environments, to create different interactive projects and activities to enhance students' e-learning.

1. Pedagogical Scenarios

Second Life is primarily crafted to be built and populated with content generated by its users–hence is a rich environment for content creation [17]. Along with creating solid or hollow inanimate objects, it is possible to place programmable scripts on these created objects to give them specific repetitive animations, or provide the objects with Artificial Intelligence (AI) awareness of the surrounding actions and events and hence react according to different situations and stimuli [18]. Inside Second Life these scripts are created using the Linden Scripting Language (LSL) and attached to inanimate objects or representations of avatars to animate them. These programmed avatars are called bots. This is done by placing the scripts on an object attached to the avatar, and it this object that runs the script and controls the avatar to appear to be walking, talking etc. [18].

Bots can perform many simple interaction tasks such as to recognize approach of other avatars, ask questions, provide pre-prepared answers to questions, follow, lead or locate other avatars, turn on or off other objects, play pre-recorded animations as responses to different stimuli, collect data or information, simulate roles e.g. patient, waiter etc. The advantage of using bots is that they appear as realistic as "real" avatars, which belong to real life users, thus as indicated by Varvello and Voelker [19] can be used to conduct endless activities, social interactions and experiments at any time of day with calculated precision and efficiency. For example, Kemp and Livingstone [20] suggested setting up "tour bot" agents inside museums to greet guests and take them on a pre-determined route with descriptions of the exhibits. The stopping points and text for the descriptions sit inside the "bots" as notecards and the Logic is implemented using LSL. Bots are being increasingly used in virtual environments [21] e.g. Second Life, for their convenience as simulation platforms for testing multi-agent systems and other AI concepts that are more cost effective to use than physical ones [22].

For the purpose of this research 2 different kinds of bots were experimented with: "Pandorabots" and "Pikkubots". These were used in association with a simulation "holodeck" as explained henceforth:

- Pandorabots are AI "minds" or "chatbots" which can be created or customised using a free open-source-based website enabling development and publishing of these chatbots anywhere on the web, including 3D VLEs like Second life. Pandorabots support the new AIML 2.0 as their knowledge content markup language. They are used due to their ease of programming and adaptability to work in any virtual reality program, for a Pandorabot mind can be easily

trained to provide certain sets of answers when asked certain combinations of questions or keywords.

- PikkuBots are bots or avatar entities created for Second Life which can be operated automatically. PikkuBot is actually a program that is usually installed on a dedicated server to automatically run inanimate avatars in "Second Life" even when the user is not at the computer. The PikkuBot can be configured to do many tasks. After installing and configuring, the bot is controlled using "commands". These are short words sent to it either using the instant messaging chat inworld (inside Second Life), typed in the command line at the bottom of the bots' GUI, or using commands sent to it directly using an inworld scripting engine placed in a concealed or visible object which triggers the command when the bot steps on it. The bots' server feeds sensory information for the characters/avatars over network connections containing the current state of the virtual world. The bots interact in the environment by sending action commands back to the server and the character moves, talks etc. [23].

- Holodecks are virtual reality platforms which can take the form of any object inside a 3D VLE but contain scripts to "rez" or materialize/create an immersive new environment around the avatar. This can be used to provide multiple alternate environments or realities, through choice from a menu, which students can engage with.

A technique to combine all 3 separate technological AI components mentioned above was used for the pedagogical scenarios presented in this research. This main merging concept for Pandorabots, Pikkubots and Holodecks was used to create multiple projects as explained henceforth. The technique used was i) Create a Pandorabot mind and train it to recognise a series of questions using combinations of keywords, then provide groups of specific answers for the bot to reply with. ii) Create/purchase an inanimate Pikkubot in Second life, customise its appearance and place the Pandorabot AI mind on it (attach it to it) to give the Pikkubot the life-like interactive conversational abilities to communicate with other real users' avatars. iii) Program a scripting engine in Second Life, a commercial example of which is "ImagiLearning Platform", which when stepped on will animate the Pikkubot's physical actions e.g. move, point etc. iv) Create/customise/script a Holodeck, build and compress all the environments/spaces/buildings which are to be rezzed from it, then place these environments inside the holodeck and script its menu to materialize them on demand. v) Adjust the scripting engine controlling the Pikkubot so that one of its commands would make the Pikkubot trigger the holodeck and rez a specific environment based on the questions and answers dialogue with the real avatar users. vi) Devise the different project scenarios to be used with the students, utilising the above created comprehensive AI system comprising of Pandorabot, Pikkubot, scripting engine, built spaces and Holodeck. Examples of this are demonstrated in the next section.

2. Project Examples

An example related to digital creativity and design modelling was a project called "Dream Environment". The purpose of this was to allow the students in a 3D

Figure 1. Pikkubots interacting with student avatars

environment to change the building style they are in to study different elements of architecture related to a certain era e.g. in an Egyptian, Chinese, Indian, Roman, Classic style temple or building. The building prototypes would be created then loaded inside a Holodeck (a commercial example of which is "Horizon Holodeck"). The student or tutor can choose whatever environment he wishes for to open up around him from a menu that appears for him inside Second Life. A Pikkubot would then appear, as shown in Figure 1, dressed appropriate to the era chosen and provide information about the architecture and design, asking questions interactively from the student. Other applications of this system can be e.g. to rez a courthouse to conduct forensic studies investigation and role-play.

"Obedient Patient" is another example of a project where bots can be trained as virtual patients, as shown in Figure 2, to give certain responses on being examined in different ways by avatars who belong to medical students training in SL on dealing with patients. This can be held inside an emergency room in a hospital rezzed from a holodeck. Furthermore 3D voice recognition can be used to provide different personalities for the replying bot.

Another example was a project called "Virtual Tourist" using the same technology to teach students about different touristic places on Earth, dangerous places or historical extinct places (could be used by any tourist unable to visit these places due to disability or time) by modeling (simulating) these places e.g. Pyramids, Eiffel tower, Everest Mountain, North Pole, Pacific Ocean, Solar System, placing them in the Holodeck (Figure 3 image 1) then rezzing them at will, with a Pikkubot to explain, provide a virtual tour and question the students. Not only can one build an environment to rez, as can be seen in environments 2 and 3 in Figure 3, but also a real-life panoramic view can be placed in the Holodeck, which would rez around the avatar and create a feeling of immersion inside it (Figure 3 environments 4-8).

Figure 2. Pikkubot posing as virtual patient

1- Holodeck platform with choice menu
2- Mansion
3- Farm
4- Real panorama of top of mountain
5- Real panorama of Paris 1900
6- Real panorama inside temple
7- Real panorama inside church spire
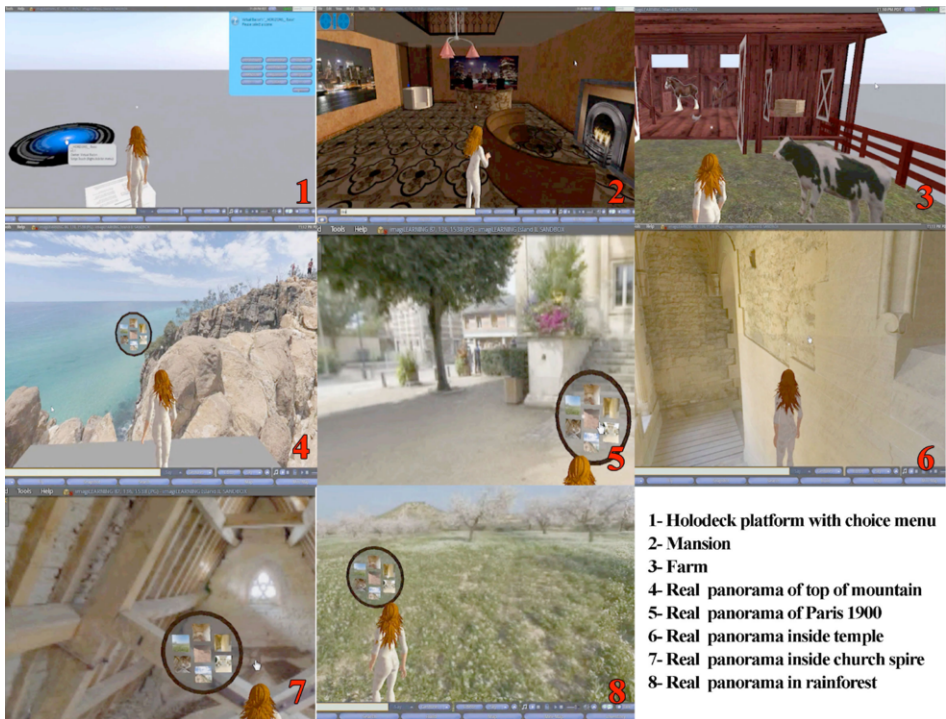8- Real panorama in rainforest

Figure 3. Holodeck and different virtual environments rezzed from inside it using a choice menu

"3D Catalogue" is another interesting project, which appealed to students. It involves creating a complete application for use by a real estate company (houses to buy or rent / hotels to choose from), where the user talks to a Pikkubot (representing an agent). The user specifies the house size he wants, number of rooms, price range

etc., and automatically samples of model house appear before him to choose from (from a holodeck) as can be seen in Figure 4. This has potential of being an online service for a real-life business.

Figure 4. Holodeck rezzing complete buildings for demonstration

"3D Exhibition" is a project similar to the above but displaying a gallery of renowned images for e.g. Monet, Renoir in the Louvre with spoken info by a Pikkubot on each (Figure 5). Another project "3D Interactive Environment" uses the Holodeck to create interactive environments e.g. how to set up alarm system, piping system, precautions in house. Figure 6 illustrates a rezzed kitchen using Holodeck. The frying pan is the Pikkubot asking questions like what to do if a pan was on fire. If you answer correctly it makes a flaring sound, if not the kitchen goes on fire, then you can reset the system again.

Figure 5. Holodeck rezzing an art gallery

Figure 6. Holodeck rezzing an interactive kitchen environment

"Virtual Sensor Simulation" is a final project example, which uses reflexive architecture techniques in SL, which use sensors to identify approach of avatars. This can be used to simulate robotic movement, car crash etc. to help with real-life design of these devices.

The 7 projects described above were piloted with samples of students at random inside Second Life. However their actual impact on under-graduate and post-graduate course remain to be investigated. One point of interest is that According to Maher and Giro [24], agents or bots can function in three modes based on their internal processes: reflexive, reactive, and reflective. Reflexive mode is where the bot responds to sensory data from the environment with a pre-programmed response or reflex without any reasoning. In this mode the bot behaves automatically with no apparent intelligence. Reactive mode is where the agent displays the ability to reason according to the input data such that the bot appears to behave with a limited form of intelligence giving different responses for different situations. Reflective mode is where the bot exhibits capacity to "reflect" on input and propose alternate actions or decisions, i.e. not simply to react but to hypothesize [24]. The projects suggested in this research demonstrate both reflexive and reactive behaviour from the bots, but not reflective. The reflexive aspect can be seen through the Pikkubots' automatically induced reactions in response to a student's action. The reactive behaviour can be seen in the interactive solutions or answers offered by the Pandorabot mind attached to the Pikkubot in reaction to a user's choices or questions. This is reactive because the bot chooses answers or actions from a database, based on its previous training by its programmer. However the presented scenarios here still need to investigate the possibility of creating reflective decision-making AI within the bots.

During their engagement in each project with the bots and holodeck, students were asked to fill in questionnaires in the form of note cards in Second Life to comment and reflect on their experience and interaction. These note cards were then shared with the researcher through a note card giver. An automatic chat log of the participants'

interactions with the bots served as the observation of the interaction that participants had with the bots. This technique was employed as previously utilised by Beaumont et al. [21]. The automatic log of the interaction that every participant had with the bots was analysed, and merits and difficulties recorded to better inform the researcher of the effectiveness of the system and ways to enhance it for future testing with undergraduate and post-graduate courses.

The main merit recognised by the students, as also identified by Muir et al. [25], was that these projects allowed the student avatars to participate in an interactive, engaging "lived experience" that would not be possible in the physical world. They could embody their character, cooperate with others and submerge themselves in an experience that could not be replicated as fully in real-life. Additionally, the free form nature of the Second Life environment meant that each session/lesson could be different, allowing for different situations to be played out depending upon the contributions of the participants. The main drawback however was that students recommended that the system needs some training or orientation before usage as it is not easy or straight forward to use especially for users who are not technologically savvy.

Finally, as claimed earlier, there is sufficient evidence to confirm that the 3D AI virtual projects created in this research satisfy the 7 conditions of constructivism previously mentioned, thus demonstrate usage of constructivism as follows:

1. Providing multiple depictions of reality – through the diverse rezzed environments
2. Focussing on knowledge construction not reproduction – by formation of knowledge through the interaction between bots and users
3. Production of genuine tasks – through innovative ideas created using the bots/holodeck system
4. Providing case-based learning environments – since each project presents a unique case study, situation or environment
5. Promoting reflective activities – through providing critical analysis and reflection on the experience in the form of questionnaires filled by the users
6. Enabling context and content dependent knowledge construction – by programming content specific scripts in the system.
7. Supporting collaborative negotiation – through the engagement of all the students in class in the experience together and contributing to the discussion with the bots

Conclusion

The Artificial Intelligence bot and holodeck system developed in this research shows how 3D virtual worlds can provide environments that can respond automatically and interactively with their users. The diversity of projects created using this system opens endless frontiers for creating student-centred and engaging educational activities to enhance a student's learning experience. As mentioned previously future research

involves enhancing the system, simplifying it and testing it with under-graduate and post-graduate students in Higher Education courses. This is in addition to investigating the possibility of adding reflective behaviour in bot actions to enable decision making to reap most value from technologically supported pedagogy.

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