The Influence of Virtual World Interactions toward Driving Real World Behaviors

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Abstract. In the recent years, virtual worlds have gained wide spread popularity and acceptance in a variety of application domains including training, education, social networking, and conceptual demonstrations. This is largely due to their ability to support modeling of fully textured high-resolution real world objects, to provide a compelling user experience, and to offer novel, rich and exploratory interactions to the user. However, the impact of familiarity with the real world domain and objects on user behavior is still unclear. In this study, we discuss the findings from a pilot study on a virtual world facility tour that was based on a real world facility. The objectives of the tour were threefold. First, we sought to understand the feasibility of using a virtual tour in lieu of the actual real world tour. Second, the tour was used as an educational tool to demonstrate several sustainable or efficient energy initiatives to the facility occupants. Specifically, the virtual tour consisted of an interactive energy dashboard, a low voltage LED based lighting demonstration, an illustration of Heating, Ventilation and Air Conditioning (HVAC) equipment operations during day and night, and renewable energy sources within the facility. Third, we sought to understand the impact of the tour on participants' future behaviors and attitudes toward sustainable energy. In order to address these overarching objectives, user feedback was collected using a survey after the users participated in the tour. We administered the survey to both occupants and non-occupants of the facility to also understand the impact of familiarity on their behaviors. Users who were familiar with the facility were optimistic about their perception of learning how to navigate around the virtual replica than those who were not familiar. Our preliminary findings from the survey indicate that virtual worlds can have a positive impact on the users' behavior. Overall, we found that users' engagement during the virtual tour could contribute to learning and the development of lasting positive behaviors within virtual world, which can, in turn, translate into real world behaviors.

Keywords: Virtual Worlds, Experiential Learning, Human-in-the-loop simulation.

1 Introduction

Virtual worlds are one of the fastest growing technology thrust areas in gaming and social networking communities. They have been applied rigorously toward training

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and experiential learning applications in the recent years (Cohn, Nicholson & Schmorrow, 2009; Nicholson, Schmorrow & Cohn, 2009; Schmorrow, Cohn, & Nicholson, 2009; Tharanathan, Derby & Thiruvengada, in press; Thiruvengada, Tharanathan & Derby, in press). With the availability of large network bandwidths, high end computing resources, advanced voice and video communications, user experience has become more lively, engaging and quite seamless within online communities. This has led to the development of many virtual worlds with varying levels of fidelity. In this research, we attempt to understand the impact of a user's virtual world interactions and experience on real world behaviors within the context of an energy sustainability initiative. We propose that a compelling interaction bundled with an engaging user experience can have a lasting impact on user's perception and encourage energy conservation behaviors.

2 Literature Review

A virtual environment (VE) is a simulated, computer generated environment that creates "synthetic sensory experiences" (Salas, Oser, Cannon-Bowers and Daskarolis-Kring, 2002). For example, users could interact with computer-generated images, sounds, and haptics. More specifically, multiuser virtual environments (MUVEs), also referred to as virtual worlds (VW), allow users to interact with other users within the simulated environment for the purpose of collaboration and knowledge sharing (Bainbridge, 2007; Salas, Oser, Cannon-Bowers & Daskarolis-Kring, 2002). Oftentimes, virtual words mimic complex physical environments and are inhabited by other users represented by animated characters, or avatars (Bainbridge, 2007). Two examples of VWs are Second Life® [1] and OLIVE™ [2].

Virtual worlds have proven to be successful within a variety of domains such as corporate training and collaboration (Heiphetz & Woodill, 2009), military training (Shines, 2002), medical training (Heiphetz & Woodill, 2009), prototype development (Linden Labs, 2009), psychological treatment (Anderson, Rothbaum & Hodges, 2001), and higher education (Wankel & Kinsley, 2009). This success can be attributed to the virtual world's ability to provide the user an immersive environment that is suitable for role-playing, problem-solving, collaboration, experiential learning, and interaction (Heiphetz & Woodill, 2009). That is, virtual worlds allow users to develop cognitive skills and acquire knowledge while being situated within an environment that mimics a real, inaccessible, and/or dangerous environment (Dieterle & Clarke, 2008; Mantovoni, 2001).

3 Virtual World Demonstration Framework

Our framework was developed within a virtual world called Second Life® to educate the visitor about the sustainability and energy initiatives that were being implemented at our facility in real world. We called it the "Golden Valley Virtual Tour" (GVVT). We adopted an iterative user centered design approach to construct the components of

[1] Second Life® is a registered trademark of "Linden Research, Inc."
[2] OLIVE™ is a trademark of "SAIC, Inc." (Formerly owned by Forterra Systems, Inc.)

our GVVT framework. The details of the user centered design approach and the individual tour stop components of our GVVT framework are discussed below.

3.1 User Centered Design

In order to engage the user effectively and deliver a compelling user experience, we followed a user centered design approach as described by Usability Professionals' Association (UPA) guidelines and User Centered Design Methodology (Mayhew, 1999). We adhered to the key steps identified within the four distinct phases: *Analysis*, *Design*, *Implementation* and *Deployment*. During the *Analysis phase*, we met with the key stakeholders including building managers, champions/members of the sustainability committee, public relations to identify the vision for this demonstration. We also identified key usability goals and objectives and transformed them into needs and requirements. A field survey of the real world facility was conducted to capture the details so that we could use them in the design and implementation phases. At this point, we identified several user profiles but narrowed it down to three key user profiles (*facility occupant, building manager, executive member*) and created detailed personas. A task analysis was conducted to identify user scenarios and user performance requirements. In the *Design Phase*, we began brainstorming design concepts and metaphors and came up with four key tour stops (*Energy Dashboard; Motion Detected LED Lighting; HVAC Day/Night Modes; Wind Turbine and Solar Panel*) for the demonstration. The specific details of each tour stop are discussed further in the rest of this section. The demonstration included an automated and interactive robot tour guide who was modeled after a real life tour guide to walk the visitor through the various tour stops in a pre-determined sequence. We developed detailed workflow and navigation for the users based on the use case scenarios identified earlier. Then, we proceeded to develop storyboards, interaction paradigms, and robot tour guide scripts for each tour stop. We documented the scripts using a standard template that was specifically designed for this demonstration. During the *implementation phase*, we conducted ongoing evaluation of the implemented prototypes during recurring meetings with the development team within the virtual world facility. We also adopted an iterative build approach, wherein, each tour stop was developed first and perfected before we constructed the next tour stop. An informal heuristic evaluation and usability testing of each tour stop was also conducted. This enabled us to work closely with the development team as the design was implemented and improve the quality of the tour stops significantly. In the final *Deployment Phase*, we conducted reviews with the stakeholders and received feedback from them using surveys to understand the effectiveness of the tour stop to achieve the goals and objectives of the user when they engaged with this demonstration framework.

3.2 Description of Framework Components

The GVVT framework components consists of the virtual facility that is a recreation of the real world facility, a robotic tour guide and four key tour stops (*Energy Dashboard; Motion Detected LED Lighting; HVAC Day/Night Modes; Wind Turbine* *and Solar Panel*) that are organized in a hierarchical manner. The hierarchical organization of our GVVT framework is shown in Fig. 1.

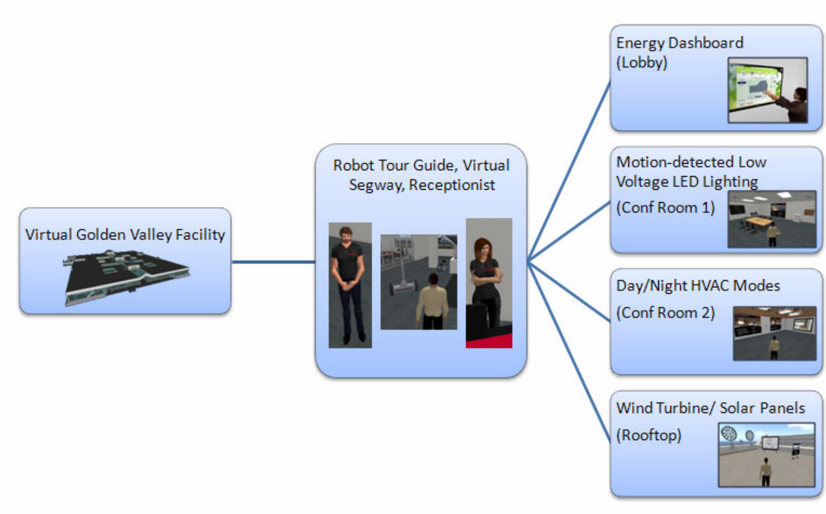

Fig. 1. Hierarchical Organization of GVVT Framework

A virtual representation of Golden Valley facility was developed. The robot tour guide that resembles a human avatar was responsible for directing the visitor through the various tour stops in a predetermined sequence. The role of the robot tour guide can be considered similar to the role a tour guide at a museum. To visit the individual tour stop, the visitor would have to first register with the robot tour guide and instruct it to proceed to the subsequent tour stop in order to experience the same. In addition, we built an alternative fully automated tour experience using a Virtual "Segway® Personal Transporter[3]", where the visitor would not have to stop and interact with the robot tour guide to proceed to the next tour stop. We also constructed an interactive and automated receptionist avatar capable of greeting the visitors (based on proximity) and providing key facts about the virtual facility when the visitor first logs into the virtual tour. This framework is robust, scalable and can be easily customized to include additional tour stops in the future. The tour stops were classified into four groups based on the mode of user interaction and level of feedback as shown in Fig. 2.

The visitors were able to interact manually with the objects of interest within tour stops 1 & 3 using their avatars either via keyboard or mouse. In tour stop 2 & 4, the location of the visitor's avatar and the proximity to objects of interest triggered interactions (e.g. Motion-detected Low Voltage LED lighting). Similarly, the visitors received limited (direct) feedback in tour stops 1 and 2 through audio narration and states of individual objects. In tour stops 3 & 4, the visitors received more (indirect) feedback through illustrative videos, in addition to direct feedback about object states and through audio narration.

[3] Segway® Personal Transporter is a registered trademark of "Segway, Inc."

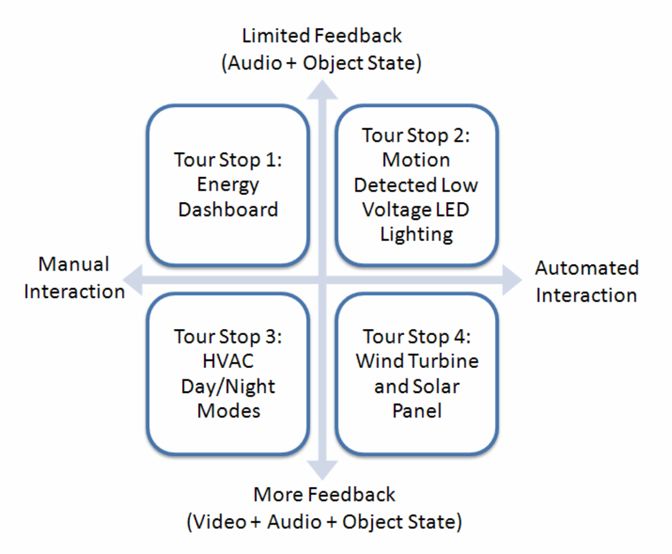

Fig. 2. Classification of Tour Stops

3.3 Tour Stop 1: Energy Dashboard

The focus of this tour stop was to inform the visitor about the current energy consumption of the building and educate them about the energy conservation measures. We composed a storyboard and script that would be narrated by the robot tour guide to inform the visitor about the significance of this tour stop in addition to user interaction methods. To achieve this goal, we used an interactive web based dashboard and superimposed that on a virtual large screen display object within Second Life®. We enabled the user's avatar to interact with the dashboard contents and review information such as current energy usage, historical energy consumption and comparison for each section of the facility, etc. This tour stop aimed at raising awareness on how the building is performance from an energy consumption perspective and how users can contribute to global energy conservation both within and outside the facility. A snapshot of the energy dashboard is shown in Fig. 3.

3.4 Tour Stop 2: Motion-Detected Low Voltage LED Lighting

In this tour stop, we aimed to inform the user about the ongoing initiative to reduce energy consumption using motion-detected low voltage light emitting diode (LED) lighting source. We composed a storyboard and script that would be narrated by the robot tour guide to inform the visitor about the significance of this tour stop in addition to user interaction methods. Each conference room is equipped with motion detected lighting controls. Sensors automatically detect when the room becomes occupied and turns on the lights. When occupants exit the room, the sensors no longer detects motion and turn off after a small period of time. To interact with this tour stop the visitor would control his/her avatar and enter the conference room which would automatically turn the lights on. The layout of this tour stop is shown in Fig. 3.

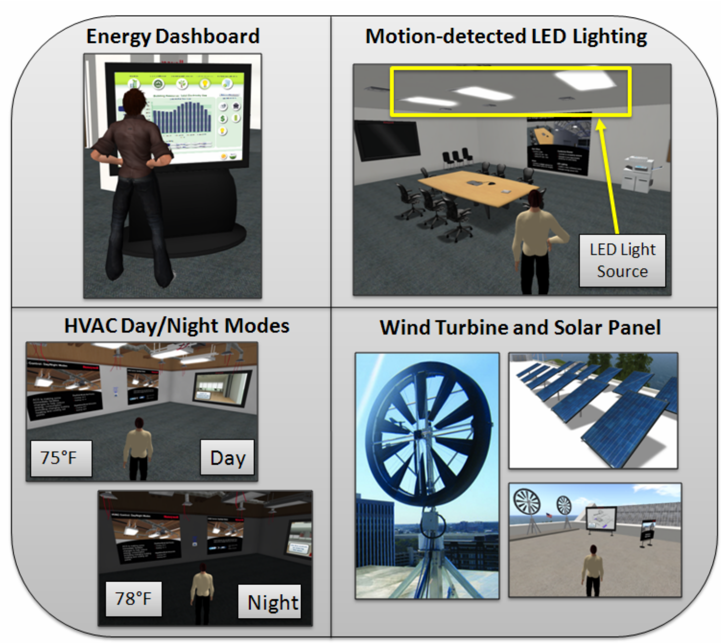

Fig. 3. Snapshot of Tour Stops 1-4: Energy Dashboard (*Top Left*); Motion-detected Low Voltage LED Lighting (*Top Right*); HVAC Day Night Modes (*Bottom Left*); Wind Turbine and Solar Panel (*Bottom Right*)

This change alone has been estimated to save roughly $1000 per hour for all of the conference and training rooms combined. In addition, the lighting in conference rooms, have been replaced with LED lighting, which is estimated to have an approximate energy savings of roughly 43%. In other areas of the building, such as in the atrium, daylight sensors detect when there is enough ambient lighting provided from the skylights. When there is not enough natural ambient lighting, then the atrium lights will turn on. In open office areas, there is also a time based lighting control mechanism that automatically turns the lights on during normal operations and turns the lights off during after hours.

3.5 Tour Stop 3: HVAC Day/Night Modes

The goal of this tour stop is to inform the visitors about the operations of the HVAC equipment and how it impacts the controls during day time (when the facility is occupied) and night time (when the facility is unoccupied). We created a storyboard and script that would be narrated by the robot tour guide to inform the visitor about the significance of this tour stop in addition to user interaction methods. It informs the visitor that the HVAC control system attempts to reduce energy consumption at night when the facility in not in use by lowering the temperature set points during the warmer months and raising the temperature set points during the colder months. By doing this, we are not continuously heating or cooling unoccupied areas of the building. It also informs the user to see how the temperature of the building changes from day to night on the virtual wall mounted digital thermostat in addition to the air flow from the ducts. In addition, a short video clip that illustrates the HVAC operations is played on a large screen display in a looped manner. This enables the user to interact, explore and learn about the HVAC operations. A snapshot of this tour stop is shown in Fig. 3.

3.6 Tour Stop 4: Wind Turbine and Solar Panel

In this tour stop, we intended to highlight the wind turbine and solar panel green energy initiatives and the offsetting benefits for using such green energy generation technology. Currently, we have installed and are testing a WindTronics®[4] wind turbine on the roof of the real world facility and replicated a similar concept within the virtual facility. It is being used to power the lighting within a corridor of our facility. This tour stop also includes an illustrative short video clip that visually informs how the wind turbine operates. We provided examples of our vision for installing solar panel arrays on the roof top and educated users the potential benefits. A snapshot of this tour stop is shown in Fig. 3.

4 Method

Participants: We conducted a preliminary pilot study using two different user groups to understand the usability and perceived impact of GVVT framework tour stops on their long term energy consumption behaviors. Group 1 had 23 participants and was called "GV". The members of this group were occupants of the real world facility and were very familiar with the physical layout and interior/exterior of the building. They had limited exposure to Second Life® and passively observed the avatar's interactions at the tour stops. Group 2 was called "DLF" and had 13 participants. The members of this group were primarily instructional designers and had some exposure with Second Life®. They were not occupants of our facility and were shown the building layout only through floor plans, photographic images of the interior and maps of the exterior of the building. They passively observed the avatar's interactions at the tour stops.

Survey: Both groups were administered a brief survey and were asked to rate the survey results based on a Likert rating scale of 1(Strongly Disagree) to 5 (Strongly Agree). The key results for the survey questions are discussed in the next section.

5 Results

The questions posed to the two groups resulted in some common themes, and also some differences between the two groups. Fig. 4 shows a normalized histogram to illustrate the differences in responses between the GV and DLF group respondents for the questions that were asked of both groups.

[4] WindTronics® is a registered trademark of "WindTronics LLC".

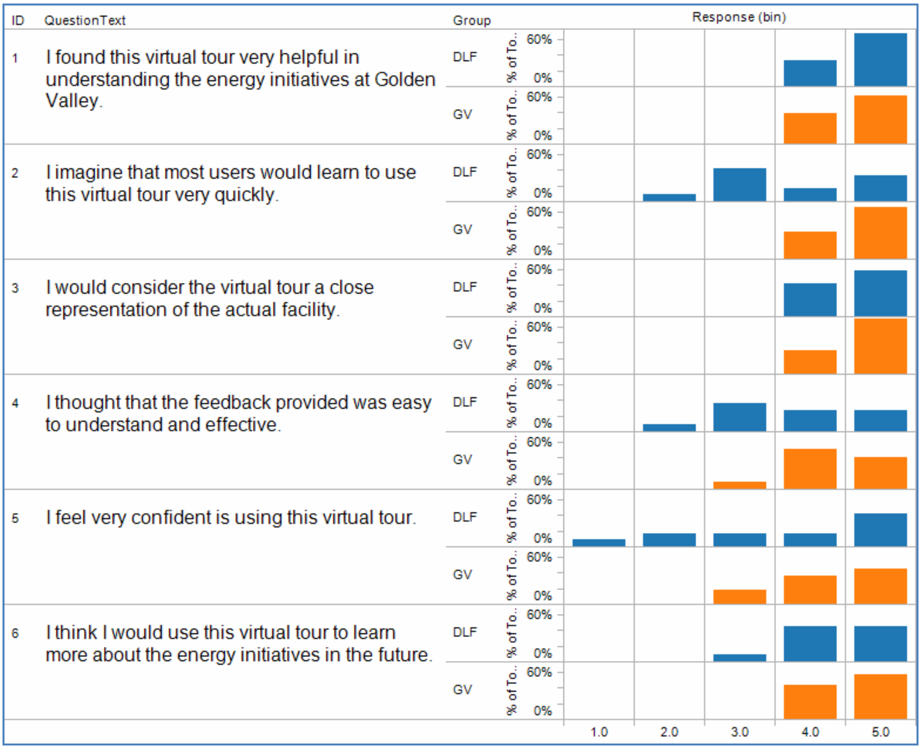

Fig. 4. Normalized Histogram of Survey Responses

Both groups found the tour helpful in understanding the energy initiatives, considered the tour a close representation of the facility, and thought they would use a virtual tour to learn more in the future. One difference noted between groups is in the level of confidence in using the tour. The DLF group tended to have less confidence in using the tour on their own. A second area of difference was in the perception of how users would learn to use the virtual tour, where the DLF group was more skeptical that end users would quickly learn. The third area of difference was in the perception of whether the feedback was easy to understand. Here, the DLF group had more spread than GV group, and also provided more comments and questions on the feedback.

The results suggest that non-familiarity with the real world facility may have negatively impacted the perceived ratings of some subjects for questions 2 (learning), 4 (ease of understanding) & 5 (confidence). Perhaps, this may be attributed to the cognitive dissonance between real world and virtual world infrastructures. Since the DLF group has never seen our facility before except in screenshots during the presentation, they were being extremely conservative in their ratings. On the other hand, GV Occupants felt that they could compensate easily based on their familiarity with the real world facility. The causal factors for this phenomenon need to be further validated with long term studies and more subjects.

Another observation is that the mode for GV group on question 2 (learning) & 4 (ease of understanding) appears to be much higher than the DLF group. A possible cause is the DLF group had an instructional design background and felt that there is a need to improve the learning deployment mechanisms, ease of understanding and boost the confidence of the user in the actual tour.

The mode for question 1 (learning) & 3 (representation) appears to be higher than the average rating (3) for both groups, which indicates that the test subjects were optimistic about being able to use this framework as a learning tool and thought that the virtual world facility closely resembled the real world facility.

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