3D Virtual Worlds: An Ethnography of Key Artifacts and Processes

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Abstract. The development of an educational 3D virtual world requires a complex skillset, which includes programming, modeling, texturing, animating, and quest/level designing. When these skills are distributed across multiple workers, the workers must negotiate a shared understanding of their intermediate work products, which ultimately culminate in the virtual world. This paper is an ethnography of the intermediate work products ("artifacts") and processes used in the development of Virtual Energy World—a 3D virtual world for instruction on sustainable energy issues. The resulting artifacts and processes have utility as a general development framework for both educational virtual worlds and video games.

1 Introduction

Educators usually have the most innovative ideas for using virtual worlds as part of their pedagogy. The problem is implementing those ideas. One option is to build over an existing virtual world like Second Life (SecondLife.com). However, building over existing virtual worlds introduces issues of student privacy, as well as issues of connectivity with other learning management systems. Flexibility is also an issue—one's ideas may be constrained by limitations in the existing virtual world's building rules and its scripting capabilities.

The most flexible solution is for the educator to develop a custom virtual world. Technology advancement combined with an abundance of free online video tutorials have made it possible for a single person to learn the skills needed to self-develop a virtual world, which include programming, modeling, and animation (Flor 2011). However, when there are time constraints and aesthetic concerns, it becomes necessary for the educator to enlist or hire specialists in each of the various skills.

This aim of this paper is provide educators a general framework for assembling a virtual world team and for organizing this team to build an instructional virtual world. The participant-observational study was carried out from January–December of 2014 in the University of New Mexico's Reality Augmented Virtual Environment (RAVE) laboratory, by the lab director and the senior members of the Virtual Energy World project team. The ethnography is based on the analysis of detailed project notes, team member reports, and work-in-progress submitted weekly and stored in a cloud repository.

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2 Overview: The Virtual Energy World

The Virtual Energy World (www.virtualenergyworld.com) is a 3D interactive visualization developed entirely by art, business, and engineering undergraduate and graduate students as part of the National Science Foundation's Sustainable Energy Pathways Through Education & Technology program (SEPTET 2012). The ultimate instructional goal of the Virtual Energy World is to educate teenage students—middle-school through college freshmen—on their renewable & sustainable energy options, as well as to develop energy management & conservation skills (see Fig. 1).

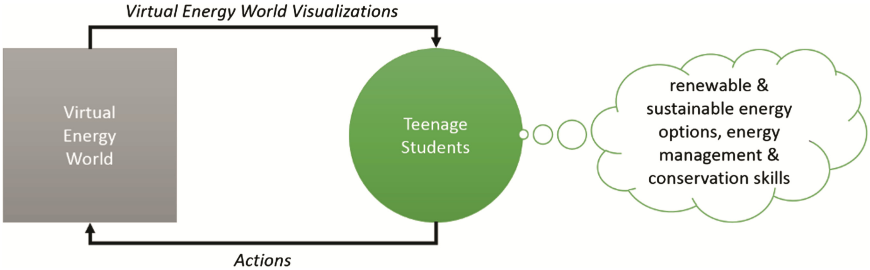

Fig. 1. Technology, Target Users, Learning Goal

2.1 The Basic Operation of the Virtual Energy World

Similar to other 3D virtual worlds, after a user selects an avatar, he or she can enter the virtual world (see Fig. 2), and interact with objects in the environment.

Fig. 2. An avatar in a virtual world, depicting a neighborhood

The key object is the house. Users are assigned a house that they can enter by clicking on the door of their house (see Fig. 3).

It is inside a user's home where an energy-themed virtual world starts to differ from other virtual worlds. Specifically, appliances in non-energy-themed virtual worlds are largely decorative and do not consume energy. In an energy-themed virtual world,

Fig. 3. A common interaction, clicking on a house's door brings the avatar inside the house

appliances have states (see Fig. 4), and when they are on they can consume variable amounts of energy.

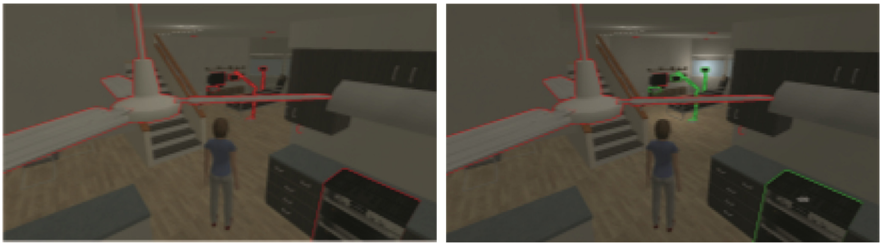

Fig. 4. In an energy-themed virtual world, appliances have states. In this example, off is denoted by a red outline and on by a green outline.

2.2 Learning in the Virtual Energy World

The Virtual Energy World is designed to be a continually evolving platform for instructing users on renewable and sustainable energy management & conservation issues in a more immersive and interactive manner than current information sources. The instructional goal of the initial implementation is to help users understand the power requirements, or wattages, of various household appliances.

Users can learn about appliance power requirements in two modes. In free-form mode, users can wander around their homes, examine various appliance wattages, and switch appliances on and off. As each appliance is switched, the virtual world displays total power usage. In quest mode, the virtual world asks users to perform various actions on appliances, or to answer questions related to power requirements. In a classroom environment, teachers can create quests for their students either to instruct students on appliance power requirements or to test knowledge of appliance wattages.

Users switch appliances on and off by either clicking or tapping on their visual representations. Appliance on/off state is denoted by a colored border, with green indicating "on" and red indicating "off." Users can reveal the wattages of appliances by either hovering the mouse pointer over an appliance or tapping & holding an appliance. The virtual world will then superimpose the wattage over the appliance along with the total power used in the upper-right corner (see Fig. 5).

Fig. 5. The coffee maker is "on" as denoted by the green outline, and the number 900 superimposed over it indicates that it is consuming 900 w of power. The 3100 w in the upper-right corner is the total wattage of the coffee maker, stove, and dishwasher.

The current implementation of the Virtual Energy World provides a minimum feature set for learning about power issues at the household level, in an immersive and interactive manner. A future implementation, currently in testing, will allow teachers to create custom quests where students can learn the energy requirements of specific appliances, or the costs of running multiple appliances over time, or different ways of conserving energy.

3 Developing the Virtual World

While it is possible for a single skilled individual to create a virtual world, to create one with a high-level of aesthetically pleasing visuals, with entertaining gameplay, and with fast performance, requires hiring different kinds of specialists.

3.1 The Five Types of Specialists to Hire and the Actual Students Hired

It was the task of the Director of the Reality Augmented Virtual Environment (RAVE) lab, which sponsored the Virtual Energy World project, to hire the student specialists. Based on his experience self-developing virtual worlds, the Director determined that there were five different kinds of student specialists needed:

1. Artists—responsible for how the virtual energy world would look. Artists could be further categorized into concept artists, inorganic modelers, character modelers, and animators.
2. Designers—responsible for how users played the virtual world. Designers could be further categorized into level designers, and user-interface designers.
3. Programmers—responsible for coding and for all technology required by the virtual world.

4. Producers—responsible for managing the virtual world's schedule, as well as acquiring sound & music, testing, and marketing the virtual world.
5. Researchers—responsible for collecting data about the real world that is relevant to the virtual world.

This list is very similar to the specialists needed to develop video games (Co 2006), which is unsurprising given that virtual worlds can be conceived as a kind of videogame with educational goals. The Director hired a total of 9 student workers to develop the Virtual Energy World (refer to Fig. 6): four artists (orange); one designer (blue); one programmer (green); a single producer (yellow); a sound & music specialist (not shown); and one researcher (black rectangle).

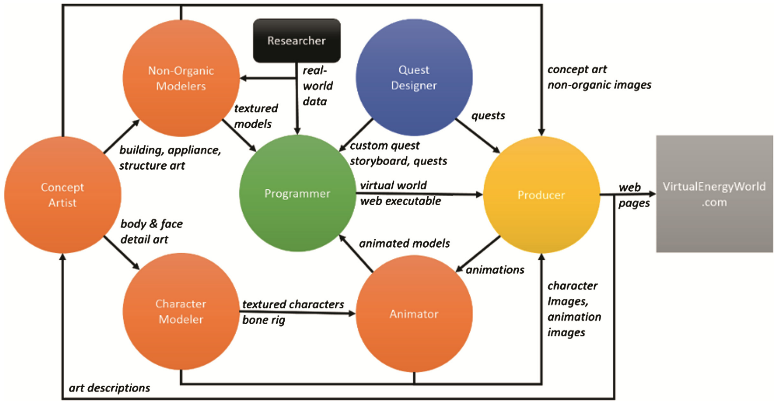

Fig. 6. General workflow process for the Virtual Energy World (Color figure online)

The particular students hired all had proven skills in videogame development and had worked together before both on a capstone videogame and on an award-winning indie videogame.

3.2 The Director's Instructions: Create a 3D Virtual World Using Scrum

The Lab Director instructed the student workers ("the team"), to create an initial version of a 3D virtual world that would increase a user's understanding of the energy requirements of typical home appliances. The only other instructions were to: (a) use *Streamline Moderne* as the artistic style; (b) use *Scrum* (Schwaber and Sutherland 2013)—an iterative method for the rapid prototyping of software; (c) to hold *weekly sprint meetings* to get feedback on work-in-progress; and finally to (d) "*check their egos at the door*" and be open to feedback from all team members regardless of specialty. All other hardware, software, design, implementation, and management details were left to the team to self-organize. The team had from January through December of 2014 to complete the Virtual Energy World.

3.3 Team Hardware and Software Decisions

For maximum access to the Virtual Energy World, the team decided that it would be implemented as a Web app running on the site VirtualEnergyWorld.com. The programmer chose Unity 3D as the game engine—an existing collection of code for displaying 3D objects & animations and for handling user interactions, which frees up the programmer to implement the gameplay and game logic. Other benefits of Unity 3D were that it was free, and that it could not only export the code as a web app but could also export the code as an iPhone, Android, or Windows phone app if the team decided that those mobile platforms were necessary in the future.

The key software used by the team included: Adobe Photoshop for creating concept art drawn on Wacom tablets; Autodesk Maya for 3D inorganic models and animations; ZBrush for 3D character models; Word Press for website content management; Trello for project management; Google Drive for sharing work-in-progress; and a private GitHub repository for sharing the code.

3.4 The Workflow that Evolved

Although neither discussed explicitly in its entirety, nor documented anywhere, the following workflow evolved (see Fig. 6).

We will focus on just the artists' work-in-progress.

Concept Artist → Non-Organic Modelers: Underspecified Detail & Team Feedback. Concept artists are crucial to the look and feel of the virtual world. They provide drawings known as "concept art" to the modelers—both non-organic and character—who then transform this art into the 3D models that are actually used inside the virtual world.

In the Virtual Energy World (refer to Fig. 7), almost all non-organic concept art consisted of a single angled view of an object. Although lacking in dimension and backside detail, this single drawing was all that the modeler needed to develop an initial 3D model. The initial model would then be subject to feedback from all team members during the weekly sprint meetings. Team feedback was key to the high quality of the final model. The modeler would get feedback from team, negotiate the changes to make, then revise and present the following week. This process would continue until the team agreed the model was finished. Thus, the final model was not often an exact copy of the concept art, but one that the artist, modeler, and team co-constructed with the aim of high quality. The team's concept of high quality was in comparison to similar art in commercial video games or in animated movies.

Concept Artist → Character Modeler: General & Focused Concept Art. Unlike non-organic objects such as buildings and appliances, where the concept artist could make a single angled drawing, a character requires the concept artist to create drawings with multiple angles (see Fig. 8) as well as close-up drawings for intricate body parts like the face (see Fig. 9). A character modeler has two options for creating a 3D character model based on concept art. He or she can either build the figure from scratch by doing a 3D papier-mâché (layering of polygons) over the drawing; or start from a base model

Fig. 7. Concept Art (left) and Final 3D Model (right)—note that it is not an exact copy of the concept art.

Fig. 8. Character Concept Art (left) and 3D Character Model without hair (right)

Fig. 9. Face Concept Art (left) and unfinished 3D Face (right)

—a featureless but proportioned 3D model—then digitally sculpt the based model to resemble the concept art.

In the Virtual Energy World, the character modeler used the base model approach. Similar to non-organic models, the model was subjected to feedback from all team members during the weekly sprint meetings, and the final model did not resemble the concept art exactly.

During one of the weekly sprint meetings, the character modeler requested more detailed drawings of the face. The concept artist responded with the face drawn from several angles (see Fig. 9, left). Like the body, the character modeler did not 3D papier-mâché the face, but sculpted a base model of the face to resemble the drawings (see Fig. 9, right).

Character Modelers → Animators: Using Prototypes to Allow Work-In-Parallel. Animators add movement to the characters created by the character modeler. In order to add movement, an animator needs not only a model from the character modeler (see

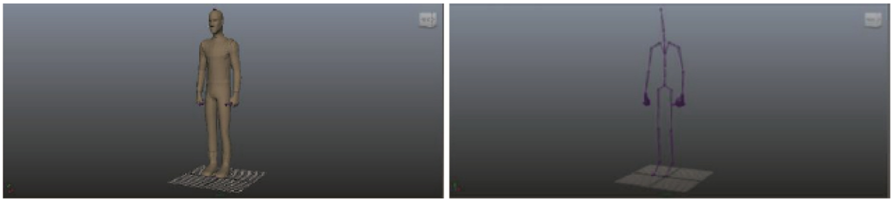

Fig. 10. The Character Model (left) and its Underlying Skeleton (right, skin hidden)

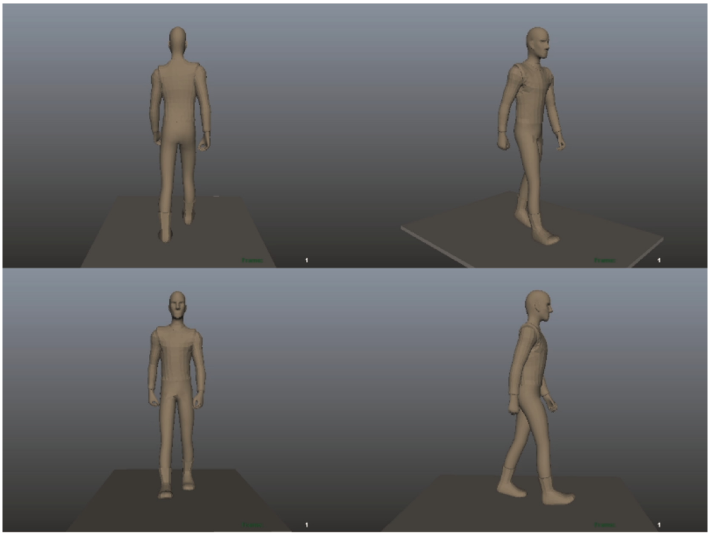

Fig. 11. Different Views of an Animated Walk

Fig. 10, left), but one that contains an underlying skeleton (see Fig. 10, right). This is known collectively as a rigged character.

From this rigged character, the animator rotates skeleton joints to simulate the angles and extensions of human movement such as walking (see Fig. 11).

The most detailed feedback during the weekly Virtual Energy World sprint meetings was reserved for the animations. The animator would create a looping video of an animation from different angles (see Fig. 11) and the team would critique many details such as the speed of limb motions, the bounce of the body, the stiffness of the torso, or under-/over- rotation of limbs. As with the models, the animator would revise and represent the work until the team felt the animation was of sufficient high-quality.

Note that the model used by the animator in Fig. 11 is a less detailed version of the final model in Fig. 8. So long as the underlying skeleton does not change, the animator could reuse his animations in the final character model. This less-detailed model was necessary because it allowed the animator to start working before the character model was completed, the latter of which took an entire semester. Without this less-detailed model, the animator would have been inactive for that semester.

4 Discussion: Virtual World as Distributed Cogntive System

A virtual world development team is a kind of distributed cognitive system (Hutchins 1995; Hollans et al. 2000). Like any distributed cognitive system, such as the brain, there are distinct modules, e.g., human vision, that specialize in transforming information into an interpretation that can serve as information for other modules. These modules are fault-tolerant—they can provide interpretations based on information that is either incomplete or underspecified.

In the case of the virtual world team described in previous sections, cognitive modules corresponded to the different student specialists. The tolerance for incomplete information can be seen in the interactions between the concept artist and the non-organic modeler, where the concept art's lack of details in terms of dimension or in terms of the backside of objects did not prevent the modeler from creating a model.

Modules upstream can give feedback to modules downstream, requesting additional information in order to complete the interpretation. This kind of feedback can be seen in the interactions between the concept artist and the character modeler, the latter of which requested additional concept art in order to complete the character's face.

There were two processes unique to the Virtual World development team qua distributed cognitive system, which are not found in neural-based distributed cognitive systems. The first was the character modeler giving the animator a prototype character so that the animator's work was not held up while the modeler finished. When the modeler did finish, the animations were simply applied to the final model. The second was the team feedback (see Fig. 12) that took place during the weekly sprint meetings, where each member regardless of specialty could critique work-in-progress. This team feedback, combined with the Scrum rapid-prototyping method were instrumental in the co-construction of high-quality models and animations.

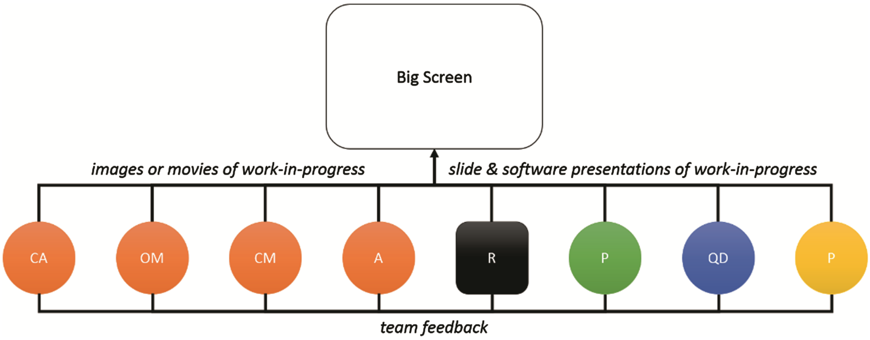

Fig. 12. Diagram of the Weekly Sprint Feedback Meeting

5 Conclusion: Developing a Virtual World

To summarize, our study suggests that for an educator to lead the development of a custom virtual world, one approach is to:

1. Determine the main idea and the target user for the virtual world, e.g., teach users about appliance energy consumption.
2. Put together a team of specialists consisting of at least a concept artist, a modeler for non-organic objects and characters, an animator, a programmer, a producer, and a researcher.
3. Communicate the main idea to the team.
4. Organize a work flow similar to the diagram in Fig. 6.
5. Hold weekly team feedback meetings (see Fig. 12), as part of a rapid-prototyping method like Scrum, aimed both at improving the quality of the work products, and at continuously expanding the main idea.

Manage the team as a flexible distributed cognitive system—allowing the specialists to negotiate between themselves their works-in-progress. Where one specialist would be held back waiting for another's work, like the animator waiting for the character modeler, ask them to find prototypes that allow them to work in parallel and to reuse their final work.

The determined educator armed with knowledge of these processes and artifacts should be able to develop a custom virtual world and contribute to the growing science of the artificial (Simon 1969).

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References

Co, P.: Level Design for Games, p. 5. New Riders, Berkeley (2006)

Flor, N.: Self-developing a MUVE for research and educational innovations. In: Vincenti, G., Braman, J. (eds.) Teaching Through Multi-user Virtual Environments, pp. 453–470 (2011)

Hollan, J., Hutchins, E., Kirsh, D.: Distributed cognition: toward a new foundation for human-computer interaction research. ACM Trans. Comput.-Hum. Interact. (TOCHI) **7**, 174–196 (2000)

Hutchins, E.: Cognition in the Wild, vol. 262082314. MIT press, Cambridge (1995)

SEPTET. Sustainable Energy Pathways Through Education and Technology (2012). http://nsf.gov/awardsearch/showAward?AWD_ID=1231046. Accessed 17 December 2014

Sutherland, J., Schwaber, K.: The Scrum Guide (2013). http://www.scrumguides.org/docs/scrumguide/v1/Scrum-Guide-US.pdf. Accessed 17 December 2014

Simon, H.A.: The Sciences of the Artificial, vol. 136. MIT press, Cambridge (1969)