

# **Virtual Cell: A Pedagogical Convergence between Game Design and Science Education**

**Anson B CALL**

**Art & Design, Architecture, Iowa State University  
Ames, IA, 50011, USA**

**Steven HERRNSTADT**

**Art & Design, Iowa State University  
Ames, IA, 50011, USA**

**Eve S WURTELE**

**Genetics, Development & Cell Biology, Iowa State University  
Ames, IA, 50011, USA**

**Diane BASSHAM**

**Genetics, Development and Cell Biology, Plant Sciences Institute  
Iowa State University  
Ames, IA, 50011, USA**

## **ABSTRACT**

Virtual Cell is a game design solution to a specific scientific and educational problem; expressly, how to make advanced, university level plant biology instruction on molecular *and* anatomical levels an exciting, efficient learning experience. The advanced technologies of 3D modeling and animation, computer programming and game design are united and tempered with strong, scientific guidance for accuracy and art direction for a powerful visual and audio simulation. The additional strength of intense gaming as a powerful tool aiding memory, logic and problem solving has recently become well recognized. Virtual Cell will provide a unique gaming experience, while transparently teaching scientifically accurate facts and concepts about, in this case, a soybean plant's inner workings and dependant mechanisms on multiple scales and levels of complexity. Virtual Cell (from now on referred to as VC) in the future may prove to be a reference for other scientific/education endeavors as scientists

battle for a more prominent mind share among average citizens. This paper will discuss the difficulties of developing VC, its structure, intended game and educational goals along with additional benefits to both the sciences and gaming industry.

## **BRIEF OVERVIEW OF THE ACADEMIC PIECES OF VIRTUAL CELL**

From a university perspective, several classical and non-classical fields of study come together to make VC, which mirrors game-making practice in the Game industry. It is common knowledge that it takes a wide variety of disciplines and skills to make effective games and VC is no different. Creating such collaboration at the university level is both challenging and rewarding.

Game Design as an academic endeavor, while flourishing at schools that reside in areas that have a high concentration of game companies, has not made as rapid pedagogical and political headway at many land grant

institutions such as Iowa State University. 3D Modeling and Animation is in a similar state, though its transition to academia seems to be more primary to Game Design as well as Scientific Visualization, both of which have been offered as classes at Iowa State University for a number of years.

Contrastingly, Biology (and other sciences) and Computer Science find themselves well established and, in the case of VC, have provided important pedagogical and funding bridges to 3D and Game Design. This model may likely be mirrored throughout the nation's state funded institutions.

### **Game Design**

Since there is no *official* Game Design emphasis area at Iowa State University, a group of faculty and students from the departments of Art and Design, Biology, Computer Science and HCI (Human Computer Interaction) have come together to form the game design personnel responsible for VC.

The VC faculty members come from Art and Design, HCI and Biology and are responsible for directing the artistic, programming, and scientific aspects of the game.

Virtual Cell is mainly a 'first person shooter' (FPS), which is game-speak when the interaction is primarily three-dimensional and seen from the player's point of view (POV). Based on up-to-date scientific facts, the game takes place inside a soybean plant cell that finds its functions dormant. The Player occupies an engineered virus, which is inserted into the non-functioning plant cell. The goal of the player is to get the soybean cell up and running which requires tiered-level, action-based problem solving, while fending off other hostile, invading viruses. The back-story involves this plant being the last to survive on the planet and necessary for terrestrial life's survival. The goal is to create an immersive and unique game experience, which through solving the cell's mechanical functions, happens to teach scientific knowledge to the player.

### **3D Modeling and Animation**

Fundamental to creating the visual pieces of VC is digital 3D Modeling and Animation. Many of today's games rely on polygon based 'game engines'. It would not be possible to make such a game without a dedicated crew of artists that are well versed in the intricacies of digital 3D design. It is their responsibility to model, texture and animate the cell pieces, viruses, and other components that will be imported into the game engine. They also provide valuable input into art direction, story line, artwork, game play etc.

### **Biology**

Integral to VC is the scientific component, which provides the background and basis for VC's story line and game style. Without the biological direction VC would be just another 'shoot-em-upper'. By using real-world plant mechanisms, VC combines the fast paced interaction that is employed by traditional games, with the problem solving more akin to strategy or turn-based games. The Player won't just run around shooting at things mindlessly, but also won't be forced to endure a slow pace either. It is the hope of the VC group that such a marriage proves unique and trend setting.

### **Computer Science and HCI**

These groups provide the programmers necessary to tackle the immense code base required for the game. VC uses a (proprietary?), in-house game engine based on OpenGL and other open standards. The programmers have focused on creating a highly portable, platform independent solution that runs on a variety of hardware. Final system requirements have not yet been determined.

### **Design**

Actual design of the game, its play style, look, feel, accuracy, storyline, interface, etc. is created through the equal interaction of all the

above groups, each relying on its strengths, skill, imagination and different thinking style.

### **Academic Challenges**

Since VC is collaboration between the Arts and Sciences, special care will need to be taken to ensure an effective interdisciplinary communication. It's not enough to simply have the right members in the group. Making a complete game from start to finish can take years (VC, as an interdisciplinary effort, and relatively new). Students may begin and finish their academic careers before the project finishes. Subsequently, there is a need for constant replenishment of human resources. Without effective leadership from the faculty, enough funding, and a clear directive; the project risks falling apart.

## **THE GAME DESIGN OF VC**

### **Technological Components of VC**

As outlined above, there are several academic components involved. The technological components are more easily understood when discussed in the context of their home academic institution.

The programming has been developed primarily at Iowa State University's HCI facility, where the engine can be tested on both standard computer monitors and the higher end virtual reality simulators. Since the 3D engine runs on OpenGL and supports stereoscopic rendering, the image output can be adapted to a variety of conventional and non-conventional display systems. However VC, as an end product, is primarily viewed as running on a capable computer with a standard display system. Since this paper is mainly a case study and overview, not a fine-combed detailing of the game's inner workings, the finer aspects of the VC's programming will not be discussed.

Sound is reproduced using OpenAL; an open, cross-platform audio protocol that echoes VC's design philosophies.

Inputs for keyboard and mouse/joystick, pinch gloves and game pads are still being considered as game style and play are worked out. However, support for these devices is anticipated at this level of development.

The artists are also working extensively with 3D technologies. Macintosh, Linux and Windows PC platforms are used to create content. Students that have already had previous 3D experience at Iowa State University have been chosen to work on the project and already have a good working knowledge of the technology that is required to develop, transfer and test their creations. The principal 3D application used are AutoDesk's Maya, 3D Studio Max and Maxon's Cinema 4D. Since all of these applications export the same polygonal data files, the student's preference can take precedence. Adobe Photoshop and Maxon's BodyPaint are used for texturing. Lighting will be the discretion of the artists but is done as part of the game engine.

While there is no *official* Game Design program at ISU, there is an award winning game development class sponsored by the department of Art and Design and has been enormously useful in understanding the manpower and technology required for VC. Most of VC's students have already had this course.

### **Game Specific Issues of VC**

There are certain reasons why the VC group chose a 3D game engine. First, that type of game is unambiguous and quickly recognized by VC's main target audience. Second is the versatility to build science-based problems while maintaining a style of play that encourages maximum exploration of the environment. Third is the flexibility to create large amounts of content that can be readily created or updated. Fourth is the portability of the engine from different display types to multiple platforms.

Story line is a critical component as this is the device that will draw the players in, get them excited, guide the science-based problems and ultimately unify the entire experience. Though the final story line hasn't been finalized

yet, the VC group has entertained various ideas. One is to have a The Hero, a student no less, enter a genetically engineered virus, which is then miniaturized and inserted into a non-functioning soybean plant cell. It is The Hero's job is to search out the many mechanisms of the cell and get them working. Guidance could come from transmissions received from a scientist, the virus itself, phenomenon within the cell, etc. so that The Hero (or more importantly, The Player) would not be lost on what the first goal would be. The virus 'ship' would have certain abilities at the player's disposal, such as the ability to release oxygen or other chemicals that are acquired along the way. Each goal achieved means more capabilities, but it also means that the player can move onto different and evermore interesting sections of the cell. The end is achieved when the cell is up and running, has passed the necessary chemicals and signals to revive neighboring cells, excretes The Hero's virus and the ship is re-enlarged.

Other variants of the story are more in-depth, such as having other students (or other people for that matter) that have previously entered the cell but failed. A secondary goal could be to save those people by getting the cell to eject them. Another aspect of the game is to fend off invading viruses that may attack the cell from time to time. The Player may engage these foes directly or use the cells own defenses or both.

The end result, we think, is a game that on the surface is not unlike many of today's popular games such as Unreal Tournament 2004<sup>i</sup>, Doom 3<sup>ii</sup>, and Rainbow 6<sup>iii</sup>, which are all based on 3D game engines that target the 18-24 age group. The main difference is that instead of teaching human warfare, VC teaches the necessary cell defenses, strategies and capabilities required to defeat invading viruses and keep itself alive.

While we think VC is unique, other notable institutions have published games to drive awareness. America's Army<sup>iv</sup> is a free, Internet download and was developed and maintained by the United States Army. This game supports multiple platforms and was

developed using many of the same open source tools as VC.

## **Game Vs. Science**

It is not desirable for VC to have the image that it is science masquerading as a game. We want people to think of it as entertainment, because entertainment is inherently a very effective way to transmit information. We do not want the game to be primary and the science secondary, but to take a more holistic approach and define it as an exciting game experience that necessarily and transparently teaches important scientific concepts and facts.

## **BENEFITS TO EDUCATION**

If successful, the results will have a weighty impact on the teaching of many subjects. Imagine a scenario where a group of senior high school students enter a physics class. At the direction of the instructor they open up their laptops and play a multiplayer physics game for forty minutes. The exercise is thrilling and engaging for the students. Before class is out, the instructor tests them on what they learned and discovers that the majority of the concepts were successfully comprehended. For example, understanding the effect of accepted physical and optical relationships by doing something as "simple" as changing Planck's constant. At the end of the session, the students don't want to quit. This is the holy grail of education.

## **BENEFITS TO SCIENCE**

A direct benefit to plant biology is the virtual world VC is creating. It is, in essence, a working simulation of a cell. While some artistic license has been taken in the interest of game play, having such a tool could prove valuable to a scientist who is interested in more sophisticated virtual simulations. VC could provide valuable direction, along with a visual way to explain thoughts and concepts for which many scientists clamor.

## **BENEFITS TO THE GAME INDUSTRY AND CONCLUSION**

Differentiation is very difficult in the game industry. There have been many attempts to create new first person shooters, with most of them becoming fairly predictable iterations of previous efforts. Hopefully VC will help further show that Gaming and Learning are not mutually exclusive, but rather can occupy the same brain-time of the player/learner. At the same time it can demonstrate that even more complex and abstract concepts can be taught more easily than using conventional teaching methods. Play is demonstrated on a daily basis to be the most effective way to teach amazingly complex and abstract inter-relationships and ideas.

With success, we can academically legitimize more forcefully and convincingly the creative partnership between technology, Game Design, 3D Design and the sciences on our nation's campuses.

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<sup>i</sup> Unreal Tournament 2004, March 2004, Atari

<sup>ii</sup> Doom 3, August 2004, Activision

<sup>iii</sup> Rainbow 6, September 1998, Red Storm Entertainment

<sup>iv</sup> America's Army, October 2002, U.S. Army