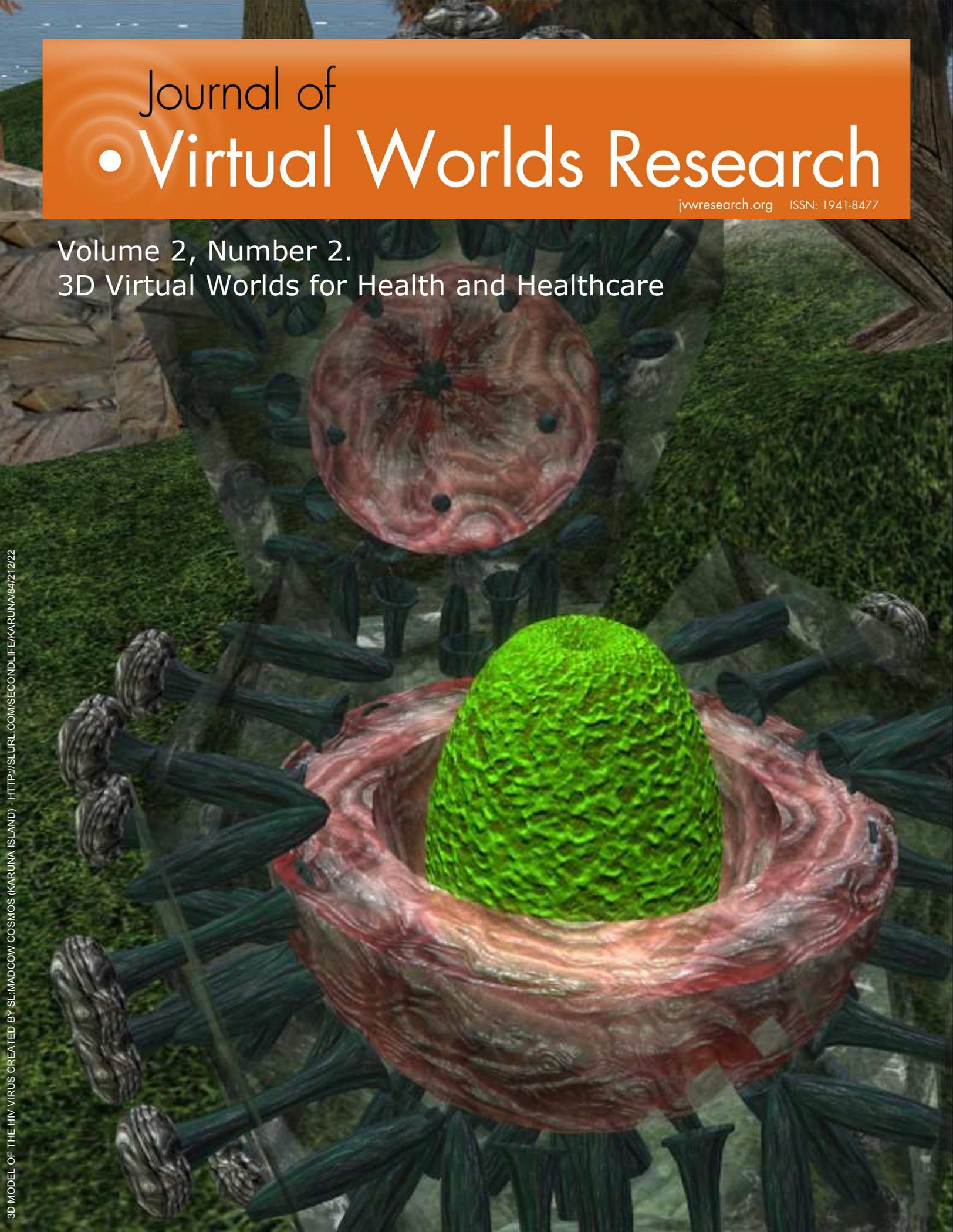


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3D Virtual Worlds for Health and Healthcare



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## 3D Virtual Worlds for Health and Healthcare

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## **Development of Virtual Patient Simulations for Medical Education.**

By Douglas Danforth, Ohio State University

Mike Procter and Robert Heller, Athabasca University, Canada

Richard Chen, Ohio State University

Mary Johnson, Florida State University

### **Abstract**

*Virtual Worlds such as Second Life provide unique opportunities to simulate real life scenarios and immerse the user in an environment that can be tailored to meet specific educational requirements. In these Immersive Learning Environments, students and faculty can interact from anywhere in the real world. From a general education perspective, they allow for virtual classrooms, virtual libraries, interactive role-playing, remote seminars, etc. From a medical education and science perspective, Immersive Learning Environments such as Second Life can be used to model doctor-patient interaction, clinical diagnosis skills, and three dimensional objects ranging from individual molecules and cells to whole organ systems, both healthy and diseased.*

*The principal goal of our project is the development of virtual patient simulations for medical education. In order to simulate real patients with greatest fidelity, the virtual patients are controlled by artificial intelligence. This allows students to engage in a natural language conversation with the patient to obtain relevant patient history, symptoms, etc, and then to develop relevant differential diagnoses and treatments appropriate for the simulated condition of the patients. Virtual world medical simulations enable students to rehearse professional behaviors in a risk-free environment, providing opportunities for skills practice prior to real-world patient encounters.*

**Keywords:** Second Life; virtual patients; immersive learning environment; medical education.

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## **Development of Virtual Patient Simulations for Medical Education.**

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Traditional medical education curricula often utilize simulated or “Standardized” patients as tools to help students develop skills in clinical reasoning, physical examinations, history-taking, patient diagnosis and generalized doctor-patient relationship (Brender 2005). Standardized patients are usually members of the local community, trained to enact a particular illness or condition. Whereas standardized patients are an important adjunct to medical education, development and maintenance of a quality standardized patient program can be costly and time consuming. In addition, students often have to work in fairly large groups and often only have brief interactions due to the limited numbers of standardized patients available. As such we have been exploring the possibility of using virtual standardized patients as an important additional opportunity for students to develop their physician-patient relationship skills. In order for virtual standardized patients to be effective, they must be able to interact using natural language conversation of the type patterned after traditional patient doctor interactions.

In addition to their conversational abilities, virtual standardized patients must be appropriately contextualized such that the immersive aspects of the interaction are maximized thus facilitating skill acquisition and student learning. In this regard, immersive learning environments such as Second Life provide unique opportunities to simulate real life physician-patient scenarios and immerse the user in an environment that can be tailored to meet specific educational needs. Second Life is being used for a wide variety of educational activities at the high school, college, and post graduate level (<http://secondlifegrid.net/slfe/education-use-virtual-world>), and more than 150 universities in the United States and around the world have a presence in Second Life (Foster 2008).

The use of Second Life for medical and healthcare education has been previously documented (Beard, 2009; Kamel Boulos 2007, Kamel Boulos 2008, Gorini 2008; Hansen 2008). Second Life has been used for disaster simulation (Kamel Boulos 2008), nursing training (Skiba 2009), nutrition education (Vital Lab 2009), etc., much of which is referenced by one of the primary in-world sources of healthcare information – HealthInfo Island (Perryman 2009) funded by the National Library of Medicine. Beard (2009) found 5 distinct health related activities in a survey of 68 health related sites in second life that were categorized into Education/Awareness, Support, Marketing/Promotion, Research, & Training.

The value of simulations in medical training is well known (Lok, 2006, Stevens et al., 2007) and virtual worlds, like Second Life, can greatly expand accessibility as well as create opportunities for real time collaborations. There are a number of SL medical simulations with actor agents behaving as patients (see Imperial College London, <http://www.elearningimperial.com>, and University of Aukland, <http://slenz.wordpress.com/2008/10/26/the-slenz-update-no-19-october-26-2008/>) Interestingly, Payr (2003) made this suggestion over 5 years ago as an example of how actor agents could be used in innovative ways as animated pedagogical agents. However, the focus of these simulations is somewhat structured, and the interactivity of the actor agent patients is very limited with little or no conversational ability. As such, we have placed a priority on the development of virtual patients who can “speak” to the students and engage in a natural conversation. Using conversational agent technology in Second Life, we have designed virtual patients that simulate the clinical interview between a doctor and patient. Our goal was to provide a realistic environment in which the students could focus on the development of their clinical interviewing skills. By increasing the fidelity of the simulated environment, we hope to deepen the immersiveness of the entire experience to better achieve the learning outcomes.

Our current project is an extension of earlier research on historical figure applications of conversational agents. Freudbot is a conversational agent programmed to chat in the first person about Freudian theory, concepts and biographical events (Heller et al. 2005). Freudbot was developed using Artificial Intelligence Markup Language (AIML), an XML-based open-source programming language, developed by Richard Wallace. AIML is the language used to support ALICE (<http://www.alicebot.org>), an award winning chatbot and progenitor of thousands of other chatbots as hosted on Pandorabots ([www.pandorabots.com](http://www.pandorabots.com)). At its core, AIML relies on pattern matching and consists of "category" tags, which in turn contain a "pattern" and "template" tag. If the input matches the pattern, the template defines the action to be taken. AIML also has recursion and wildcard functions which allow many inputs to match a single pattern. Creating content for Freudbot involved anticipating the questions users would ask of Freud and providing appropriate answers. However, adding content to AIML agents is an iterative and incremental manual process where user input is targeted for failed matches and new content is added. In addition to programming content, AIML can also be used to manage the dialogue and create strategies loosely consistent with Speech Act theory that direct the user to ask about content within each agent's repertoire. In Freudbot's case, when no input was recognized, the agent would default to one of several conditional strategies: ask for clarification, suggest a new topic for discussion, indicate that he had no response, ask the user for a suggested topic, or redirect with a unrelated question. Freudbot has been evaluated in two studies thus far (Heller et al. 2005; Heller & Procter, 2009) and although there is still room for improvement, the concept has proven to be generally positive among users.

More recently, Freudbot was successfully deployed in Second Life using an avatar connected to an AIML server (<http://slurl.com/secondlife/Athabasca%20University/194/155/249>) and served as focal point for the current project on virtual patients. The use of AIML agents in Second Life is well established. In particular, Daden<sup>1</sup> Ltd., one of the premier providers of conversational agents, has used AIML to develop agents that assist in marketing, search functions, and help desk scenarios (<http://www.daden.co.uk/chatbots.html>). Daden's agents are designed to provide flexible solutions for a variety of commercial applications. Our approach has been to focus specifically on creation of virtual patients for medical education with the goal of creating a dedicated yet scalable solution that can be implemented by physician and basic science educators for training basic interview skills for medical and nursing students.

### **The Virtual Patients**

The principal scenario underlying the Virtual Patient project is the initial doctor-patient visit. This could be for a routine annual exam, a prenatal visit with an OB/GYN, or a patient presenting to the physician's office or emergency room with a chief complaint or illness (Figure 1).



**Figure 1.** Typical setting with Student doctor and virtual patient.

The student then proceeds to interview the patient gathering appropriate patient and family histories, symptoms, complaints etc. The patient answers the questions with the preprogrammed responses for the questions asked. Once the student has gathered enough patient data they then develop a differential diagnosis list of likely causes for the symptoms described and order the appropriate lab tests, ultrasounds, x-rays, etc. Once they interpret the results provided, the students must develop a final diagnosis for the patient. The conversational components of the interaction are handled by AIML and the remainder is managed through scripting within the Second Life environment.

Our current visual design is a work in progress with plans to create more realistic hospital settings and improve the interface for creating differential diagnoses and selecting appropriate tests. We will model this on our existing electronic medical record so the students will have a common frame of reference. We hypothesize that as the fidelity increases between the simulation and the actual event, so does the level of immersion which in turn promotes positive learning outcomes.

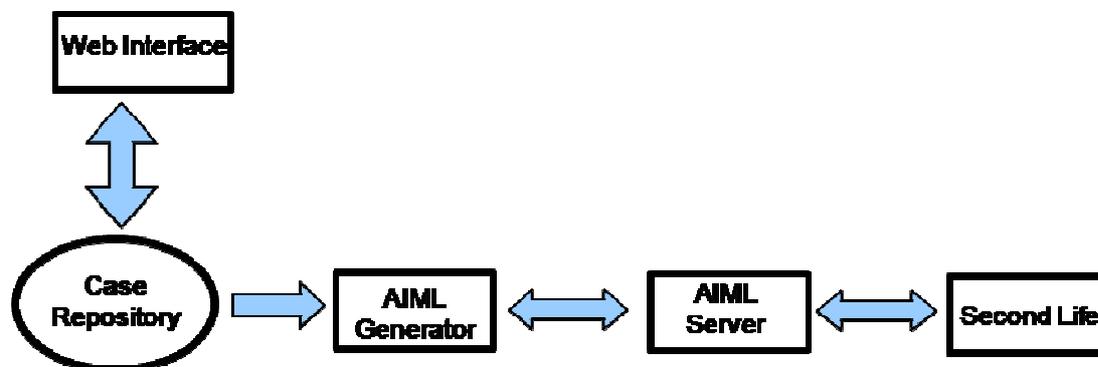
The core component of the system is the relational database for creating and maintaining virtual cases. We had several design goals when developing the virtual patient database:

1. Flexibility – As much as possible we wanted this to be platform independent. Thus, while the initial implementation is designed for a Second Life simulation using an AIML-based conversational agent, there are plans to increase flexibility by incorporating XML data which should, in principle, make it relatively easy to implement using other interfaces and conversational engines.
2. Ease of use – Cases and patients should both be configurable without requiring scripting or programming skills. Once implemented, the system should be maintainable by the subject experts (medical students and faculty).

3. Scalability – Within reason the only thing limiting how many cases, or how many patients would be expandable computing resources (clients and servers).
4. Portability – Ultimately we would like to define a standardized format for the conversational knowledge-base, allowing for easy sharing and use by other applications.

The system is composed of the following components:

- Case Repository
- Web interface
- AIML generator
- AIML server
- Second Life scripts



### *Case Repository*

The system is built around the concept of a "case repository", containing the content, or knowledge, that the virtual patient needs to perform its task, decoupled from AIML or any specific conversational engine. A single case defines the data for one type of patient condition, such as "endometriosis" or "ectopic pregnancy". This supports ease of use by allowing subject experts to work directly on the data without concern for the underlying AIML, through a variety of different tools. We achieve flexibility if the repository is constructed in a platform independent way that allows us to build tools that accomplish the following goals:

- Maintain the dataset (web page, GUI applications, automated applications such as spell-checkers, syntax checkers, etc). We have concentrated initially on a web based tool.
- Generate interfaces to the data (converters for AIML and other conversational agents). An XML to AIML converter has been developed.

The case repository consists of two parts: 1) a questions database used by all cases; and 2) case answers which contain the answer elements linking back to the respective question elements.

The questions database contains all common questions that might be asked for any patient condition. As new questions are identified, they need only be added to the questions database once, and then will become available for all cases. Generally a case will only need to have specific answers for a relatively small subset of these questions. Default answers will be defined for all questions, so that a patient is still able to respond to questions that are not particularly relevant to the case and have therefore not had case-specific answers defined. Sets of default answers (templates) will be created for different patient profiles (age, sex, marital status, etc). Building a case starts by choosing a template relevant to the patient and providing answers to only those questions relevant to the patient's condition.

### ***Web interface:***

The purpose of the web interface is to allow subject experts to build and maintain the questions and case datasets without having to understand or interact with the underlying database.

### ***AIML Generator***

The AIML generator is a Java application that converts case files to AIML for the conversational agent. This content AIML is combined with common AIML files which handle generic conversation-related behaviors and avatar control.

### ***AIML Server***

The AIML server is an open source program – (Program D serve) with an HTTP server component. SL scripts access this service via typical HTTP request functions (similar to pandorabot.com).

### ***Second Life scripts***

These scripts provide an interface between SL users and AIML server, avatar animation and other interaction with avatars and in world objects.

## **Future Development**

Although the existing application provides a rudimentary, usable virtual patient, the immersive experience will be further enhanced, and greater utility will be achieved, as the following are developed:

### ***Animation***

The virtual patient employs some fundamental animation, such as standing when someone enters the room, sitting and typing (a common method to indicate "speaking" in Second Life). Additional animations and movement, such as head turning, nodding, fidgeting and walking will help to make the patient appear more human-like.

### ***Emotional Expression***

By linking facial expressions to the conversational output, we take greater advantage of the bandwidth of communication available in a 3D world.

### ***Patient Emotional State***

Allowing for variations in the virtual patient's emotional state allows us to mimic real life patient interviews to a greater degree. Confusion, levels of cooperation, fear and other emotions can affect the way in which questions are answered and the types of questions a medical professional would need to ask to get the necessary information.

### **Conclusion**

In summary, the creation of virtual patient simulations using the Second Life platform will provide truly unique learning opportunities for the next generation of future physicians. By fostering global, interactive, immersive collaborations, we can leverage existing and future technologies to maximize educational opportunities at home and around the world. The “Millennial Generation” of students will no longer be served by the passive approaches and technologies of the past. The traditional paradigm of didactic presentation and passive learning is rapidly being supplanted by novel approaches using new technologies designed to foster active learning and participation. Immersive Learning Environments such as Second Life offer unique opportunities to engage today’s students in innovative and exciting ways.

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<sup>i</sup> **NE.:** Daden has already developed Virtual Patients Scenarios (see, for example, Virtual Patients In Second Life, David Burden Daden Limited  
[http://www.medbiq.org/events/conferences/2009/presentations/20090429\\_Burden\\_D\\_PLENARY.pdf](http://www.medbiq.org/events/conferences/2009/presentations/20090429_Burden_D_PLENARY.pdf)