Creative Educational Use of Virtual Reality

Working with Second Life

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Virtual reality has been widely proposed as a major technological advance that can significantly support higher education. VR technology is expected to facilitate

- visualizing abstract concepts;
- observing events on macro and micro scales; and
- interacting in ways that usually aren't possible owing to distance, time, or safety issues.

In many educational cases, VR technology can

- stimulate interest,
- improve conceptual understanding,
- provide immersive and interactive environments for learning by doing, and
- enhance the transfer of skills to the real world.

An important educational application of VR is virtual worlds. Universities and other educational institutions are increasingly using existing virtual-world platforms to facilitate teaching. In virtual worlds, students can learn tasks or create projects through their avatars. They can carry out tasks that could be difficult in the real world owing to constraints and restrictions such as cost, scheduling, or location.

We used the virtual world Second Life (SL) to help students learn the relationships between key concepts in designing clothing for functional comfort. We aimed to stimulate more fluid interaction between exciting general learning technologies (in this case, SL) and emerging tools (CAD for clothing thermal functional design—CTFD) while incorporating current research (on functional fabrics and high-performance sportswear) in a specific domain (CTFD).

Second Life

More than 400 educational institutions deliver educational programs or maintain a presence on SL. SL offers a ready-made platform for advanced educational use with the potential for many kinds of simulations beyond real-world experiences. It can provide exploration-based activities that epitomize dynamic and active engagement, under authentic learning conditions. It has also been acknowledged as an important tool for supplementing professional training. One academic area that commonly uses SL is design training.

SL users (*residents*) create content through 3D modeling tools and the Linden Scripting Language, which is based on languages such as HTML and VRML (Virtual Reality Mark-Up Language).

Users enter SL via their avatar, whose appearance is customizable. Avatar appearance and behavior are important in avatar-based virtual worlds because users employ avatars to interact with each other. In some virtual worlds, users create avatars according to rules given by the virtual environment (for example, for role playing). In SL, users have a greater ability to modify their avatar's appearance and behavior, to overcome the physical world's restrictions and norms.

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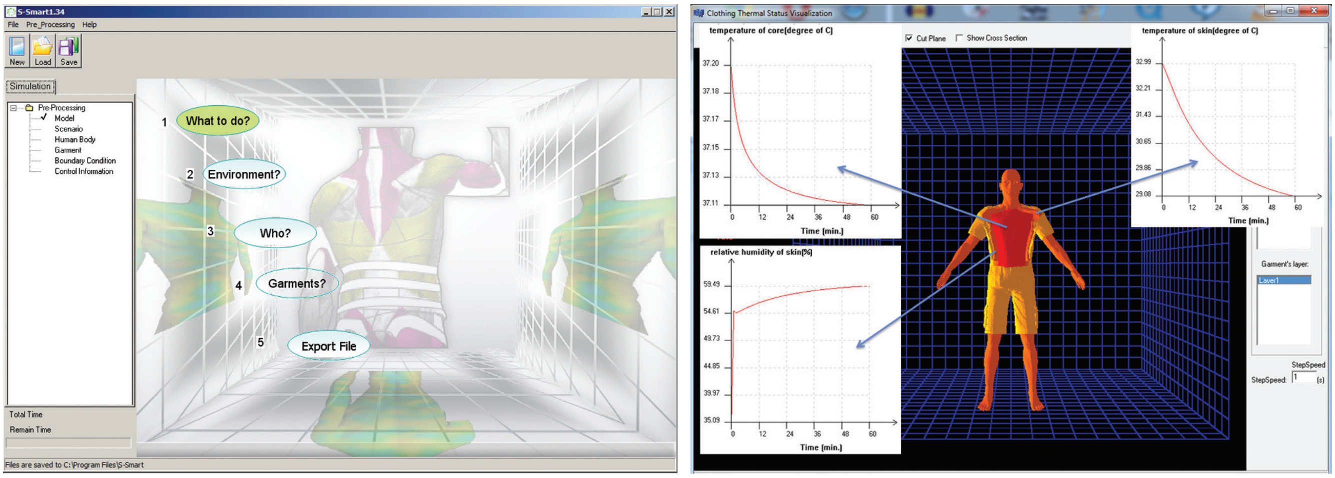

(a) (b)

Figure 1. A CAD system for clothing thermal functional design (CTFD). (a) A preprocessing module for designing case files for the computational-processing module. (b) A postprocessing module for visualizing the computational-processing results in 2D or 3D. Unfortunately, CAD-based education ignores the conceptual understanding of CTFD.

From Computational Modeling to SL

CTFD aims to create conceptual (paper-based) or prototype (physical-model) clothing that achieves desirable thermal functions and performance for people living in a range of climates and weather conditions. It focuses more on thermal functions and performance than on fashion. Traditionally, educators have employed computational-modeling technologies to teach students about the complex human-body–clothing–environment system. However, computational-modeling research is too difficult to explain to undergraduates in textiles and clothing by traditional teaching methods, for three reasons.

First, computational modeling focuses on specific physical or physiological (or physical–physiological) effects and processes, such as the relationship between body mass, level of exercise, and external temperature and humidity. The interactions between these effects and processes are so complex that it's nearly impossible for beginning students to acquire a holistic understanding of the practical interactions between the body, clothing, and environment.

Second, computational modeling doesn't let students flexibly modify the input parameters to observe the corresponding output effects. So, students have little opportunity to ask what-if questions.

Finally, students can't use computational modeling to design prototype products, which is important to apply the knowledge and skills they've learned.

On the basis of these considerations, we employed a CAD system (see Figure 1), developed with mathematical modeling, as an engineering design tool to help students learn CTFD in a scientific and quantitative way. However, CAD-based CTFD education typically focuses on procedural understanding. That is, it offers instructions for tools (for example, how to input data, change a variable, and get the results). Unfortunately, it ignores the conceptual understanding of CTFD. To improve students' conceptual understanding, educators should provide multilevel learning content, as we describe later.

To provide an environment for students' conceptual understanding of CTFD, we employed SL, which has these advantages:

- It's a 3D platform accessible to millions of users worldwide.
- Users can experience highly realistic virtual try-ons (in which 3D avatars wear the virtual clothing).
- Users can switch roles (through avatars) to express their individuality.
- SL supports an environment for users to communicate and collaborate.

However, SL has three main disadvantages. First, it has limited capability to display data in a detailed way (for example, fabric properties). Second, it only supports virtual clothes and motions with preset formats (for example, users can't freely upload their own virtual clothes and motions). Finally, virtual try-ons emphasize physical rather than functional effects (that is, SL focuses more on appearance than function).

Using VR in SL

Our creative use of VR in SL dealt with both technical and educational issues.

Technical Issues

Virtual try-ons' popularity has been increasing for both in-store and online clothing shopping.[1–3]

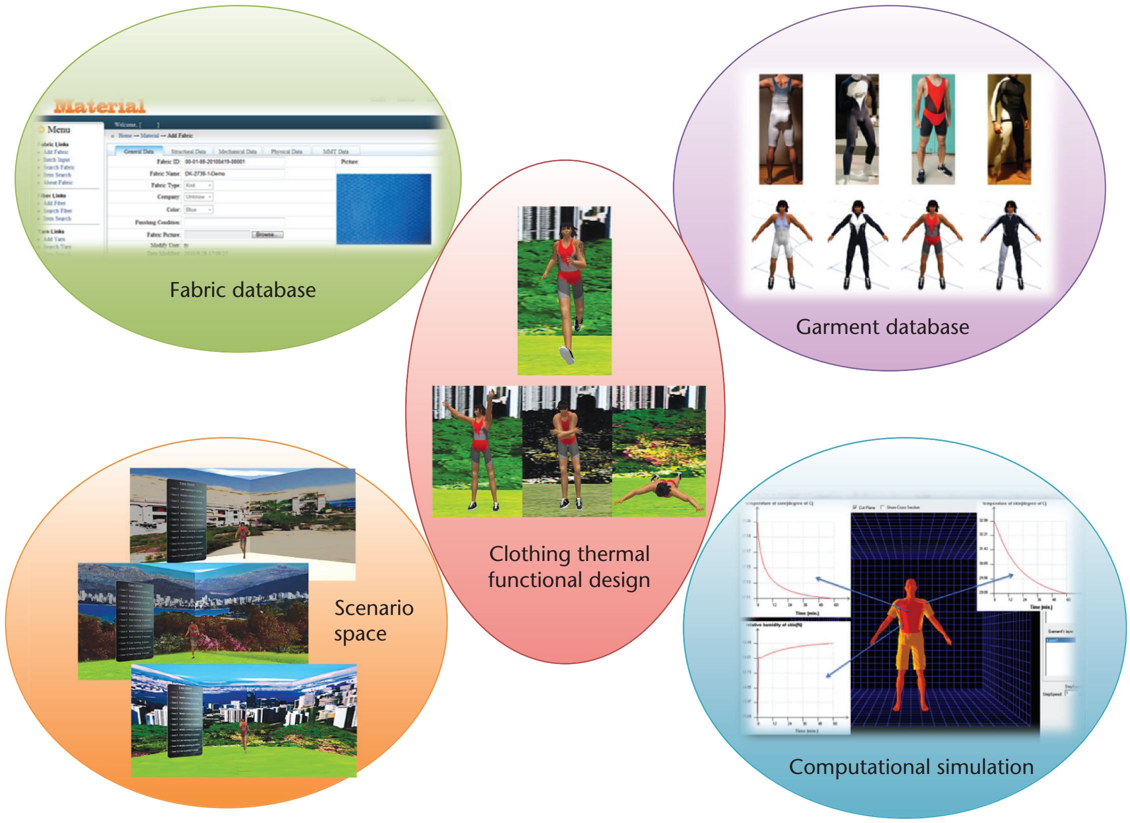

Figure 2. The framework of virtual try-on for CTFD. We developed virtual try-on using database, computational-simulation, and virtual-world technologies.

Virtual try-on applications have been based on Web technologies,[4] CAD/CAM,[5] or augmented reality.[6]

We developed virtual try-on for CTFD using database, computational-simulation, and virtual-world technologies (see Figure 2). Fabrics and clothing databases provide the specific, structured data for the computational simulation. Users can employ our CAD software to design and conduct a group of simulation cases.

Our work on the technical issues involved four objectives. First, we wanted to link the virtual fabric in SL with the fabric database (see Figure 3a). Clicking on a piece of virtual clothing opens a window in which students can click on fabric property buttons to see the related data.

Second, we wanted to convert images of real sportswear to SL virtual clothing (see Figure 3b). On one hand, we hope that the virtual try-ons are as similar as possible to trying on real clothing. On the other hand, the virtual clothes should satisfy the required SL format so that all human-shaped avatars can wear them.

Third, we wanted to simulate the environmental effects of four seasons in three locations with typical climates (Vancouver, Hong Kong, and Basra; Figure 3c shows Vancouver). For virtual try-ons in different locations, environmental conditions play an important role in CTFD.

Finally, we wanted our CAD software to be able to design simulation cases that support visualization of virtual try-ons in the scenario space (see Figure 3d). Traditional virtual try-ons focus on how the clothing looks on the human body. In contrast, our virtual try-ons focus on the clothing's thermal functions and performance.

Educational Issues

To provide an environment for experiential learning that gives students a conceptual understanding of CTFD, we designed three staged learning modules. The modules cover virtual fabrics, virtual clothing, and virtual try-ons. Educators can teach multilevel content:

- low-level learning involving concepts (for example, thermal insulation and moisture management),
- middle-level learning involving instances (for example, six virtual fabric samples and four kinds of high-performance sportswear), and
- high-level learning involving simulations (for example, virtual try-ons).

Our adaption of SL for CTFD incorporated this multilevel learning with specific tasks for students (see Figure 4).

The Case Study

We used SL with 127 undergraduates at Hong Kong Polytechnic University to teach these concepts:

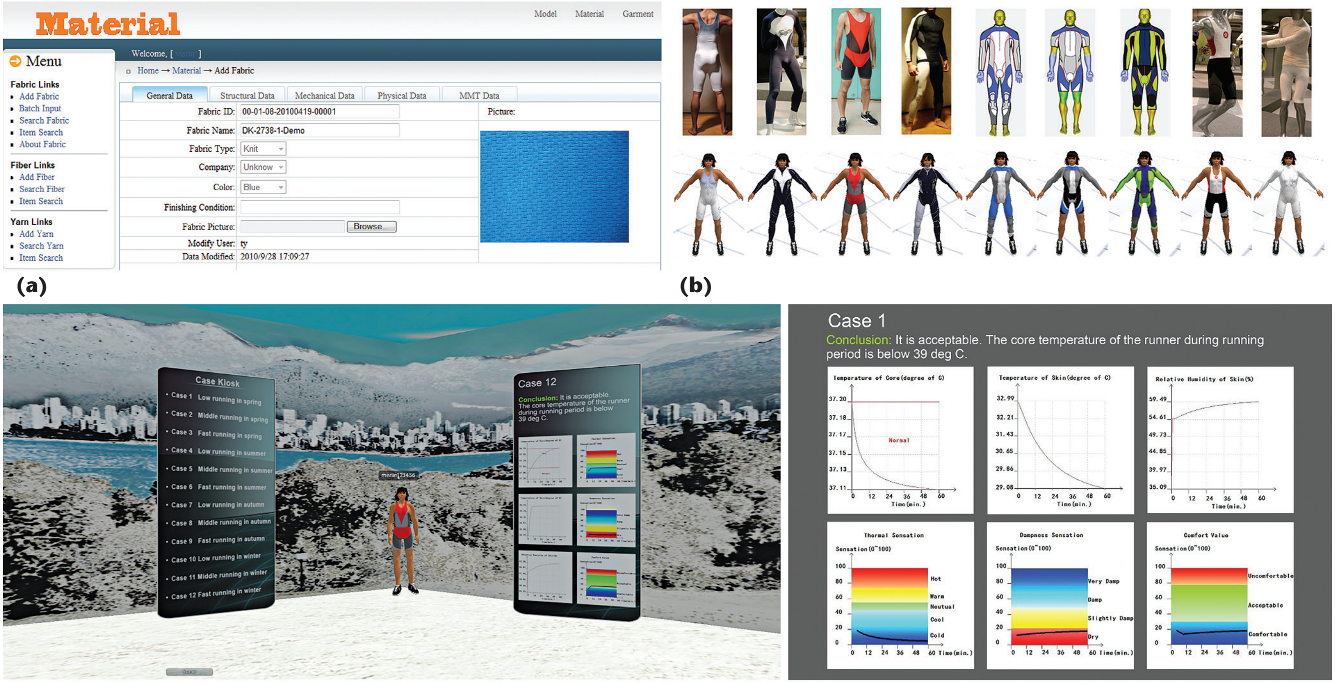

Figure 3. Creative work on technical issues. (a) The general data for fabric. (b) Virtual sportswear built for Second Life (SL). (c) Virtual Vancouver in winter. (d) Simulation results for a case in the Hong Kong scenario. The results provide the basic conclusion for the simulation and the supporting data—three kinds of thermal functional data (the top graphs) and three kinds of thermal performance data (the bottom graphs).

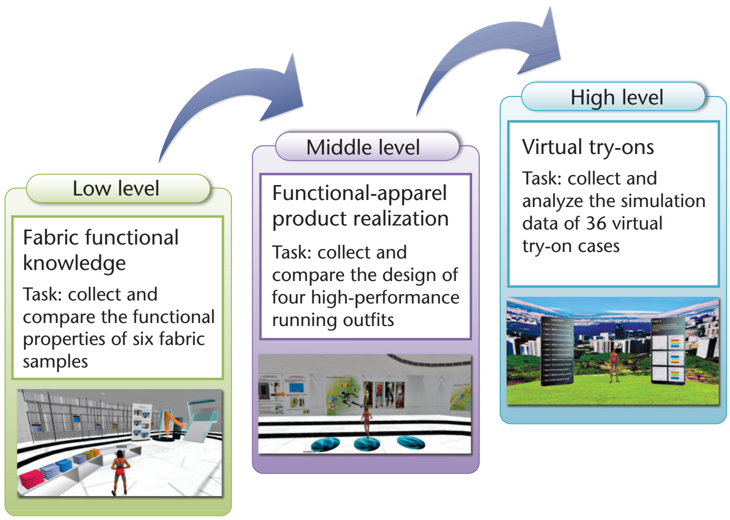

Figure 4. Learning design in SL. Three modules provide an environment for experiential learning that gives students a conceptual understanding of CTFD.

- functional-clothing products' market potential, for the course Fashion Product Development;
- CTFD, for the course Design for Function and Performance; and
- thermal stress in personal protective clothing, for the course Personal Protective Equipment in Infection Control.

The students' test performance showed that their knowledge of the content improved significantly after interacting in SL (see Table 1).

A post-study survey collected students' attitudes toward using SL; Figure 5 shows the results for the course Fashion Product Development. The most positive response was that learning with SL was fun. Students also thought that SL aroused their interest and provided an interactive learning environment. Generally speaking, they enjoyed learning with SL.

On the basis of our experiences, we offer the following tips. First, educators should incorporate into SL

- new research results (as new learning modules or materials) and
- new learning technologies.

Second, when deciding how to employ SL, educators should consider

- the content and learning objectives,
- existing learning technologies' advantages and disadvantages, and
- the students' backgrounds.

In summary, educators should comprehensively and creatively deliberate over VR's educational use.

Table 1. Students' test performance for three courses employing Second Life.*

Course	No. of students	Pretest		Post-test	
		Mean score	Standard deviation	Mean score	Standard deviation
Fashion Product Development	38	3.0	1.4	9.5	1.6
Design for Function and Performance	47	3.2	1.5	7.5	2.9
Personal Protective Equipment in Infection Control	42	6.2	1.7	9.8	0.7

The highest-possible test score was 10. In each of the three cases, the statistical significance was <0.001.

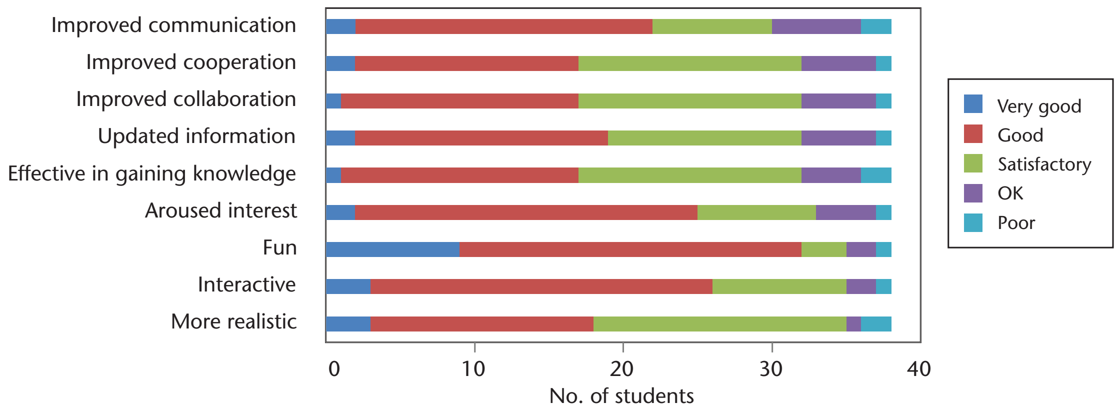

Figure 5. Survey results indicating students' attitudes toward SL in the course Fashion Product Development. They generally enjoyed learning with SL.

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