A VIRTUAL WALKTHROUGH OF AN ENERGY CONSCIOUS SINGLE-FAMILY HOME

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Abstract

With the advances in information technology (IT) over the last decade, the traditional teaching format of having an individual lecture to an audience has been supplemented, and in some cases, replaced by the rapid development and implementation of new distance learning methods. It is becoming increasingly important to develop web based 3-D visualization and animation to explain the various environmental conscious concepts and elements. The objective of this research paper was to showcase the energy saving elements used in an energy conscious single-family home design using 3D animation and virtual walkthrough. The model and animation can act as an excellent teaching tool to explain the various concepts integral to an energy conscious design, as the instructor would present the entire scheme in a virtual world so that the students can understand the concepts with more clarity and ease. The model would also help generate awareness among common people about energy conscious design as the web interface is easily accessible and user friendly.

Introduction and Background

Classroom use of IT for teaching science, engineering and technology has increased dramatically in recent years and has proved to be very effective in various situations (Haque 2001, 2003, 2004). Contemporary applications of IT allow us to develop learner-centered virtual design studios that can be reached to a large student population via the web. Enhancing World Wide Web developments, the new opportunities for interactivity and flexible access to various media format (text, sound, static illustrations, 2D and 3D dynamic illustrations, Virtual Reality worlds) challenge the traditional experience in shaping learning environments for web-based education (Klett, 2002). The student-centered distance-learning archetype should include dynamic demonstration of theoretical engineering models allowing students to manipulate, experiment, and translate theories into real-world applications (Haque 2003). Visualization is an important factor in modern education. Traditional lecture format teaching methods sometimes fall short of conveying the complex analysis and design principles that need to be mastered in reinforced concrete design course. One of the methods of reducing this short fall is to use simple animated virtual models, which demonstrate basic structural design concepts that can be used to enhance the students understanding. The interactive computer aided learning (Haque 2001) allows students to proceed at their own pace, motivated by a curiosity about "what happens" interactivity and "the need to know" the design/ analysis principles.

Visualization has always been an important aspect in the construction industry and construction education has always laid stress on that aspect. Design professionals and educators used drawing as a practical tool for seeing, thinking and understanding their ideas, and for communicating them to others. In education, drawing was often woven tightly into curriculums and it was expected to play a major role in developing students' visual abilities (Anderson, 2002). With the advance of technology 3D visualization has become very user friendly and objects that were restricted to drawings in paper can today be viewed in a 3D environment with ease. The Internet revolution has also changed the world of education with distance learning becoming a more convenient, accessible and lucrative.

Nicholson, L, (2004) is of the view many construction contracts nowadays are of design built nature which requires the construction company to be involved in creating a design that includes construction expertise, often of the green building nature. Thus the design built company is strongly placed to suggest and argue for inclusions green building technologies and design elements with an initial increased cost but in the along reduce the environmental impact and improve the quality of the built environment thus benefiting all. This advantage of in favor of the construction company can bring in more work from the same client. He further believes that the growing awareness of about green buildings and the increased implementations of green technology make it absolutely necessary for students to be familiar with the green building movement. Students will be expected to implant environmental conscious features into the building design and construction, as this would greatly benefit the end user, society and nature as a whole. Thus he feels that it is the responsibility of educators to seek out information and include it in the coursework.

Riley, D., Workman, E. (2003) are of the view that increased importance is being placed on the design and construction of buildings that are healthier for the occupants and have minimal negative impact on the environment as buildings and their construction processes are significant contributors to environmental degradation. Thus the need to minimize the effects of buildings on the environment becomes increasingly relevant. Worldwide efforts have resulted in the acceleration in the development of new "green" building technologies, which are constantly challenging AEC professionals and students to explore unfamiliar building alternatives. Firstly, this makes it imperative to develop evaluative skills that will allow the assessment and test the appropriateness of these unfamiliar technologies. Secondly emerging professionals must be equipped with the necessary knowledge and skills required to design the most energy conscious building.

Hence, it is increasingly becoming important to develop a web based 3-D visualization and animation to explain the various environmental conscious concepts and elements. The objective of this research was to develop a virtual tour of an energy conscious building showing the various concepts, elements and technical aspects of the building.

Development Methodology

The main thrust of the research was the development of a 3D computer generated animation model showing and describing in detail the various elements of an energy conscious architectural design. The following steps outlines the methods used to achieve the above stated purpose. Figure 1 shows the work flow diagram

1. Design and Development: The first step was to design and develop a typical single-family three-bedroom house. Energy consciousness was the prime-governing factor for the design and development of the house. .

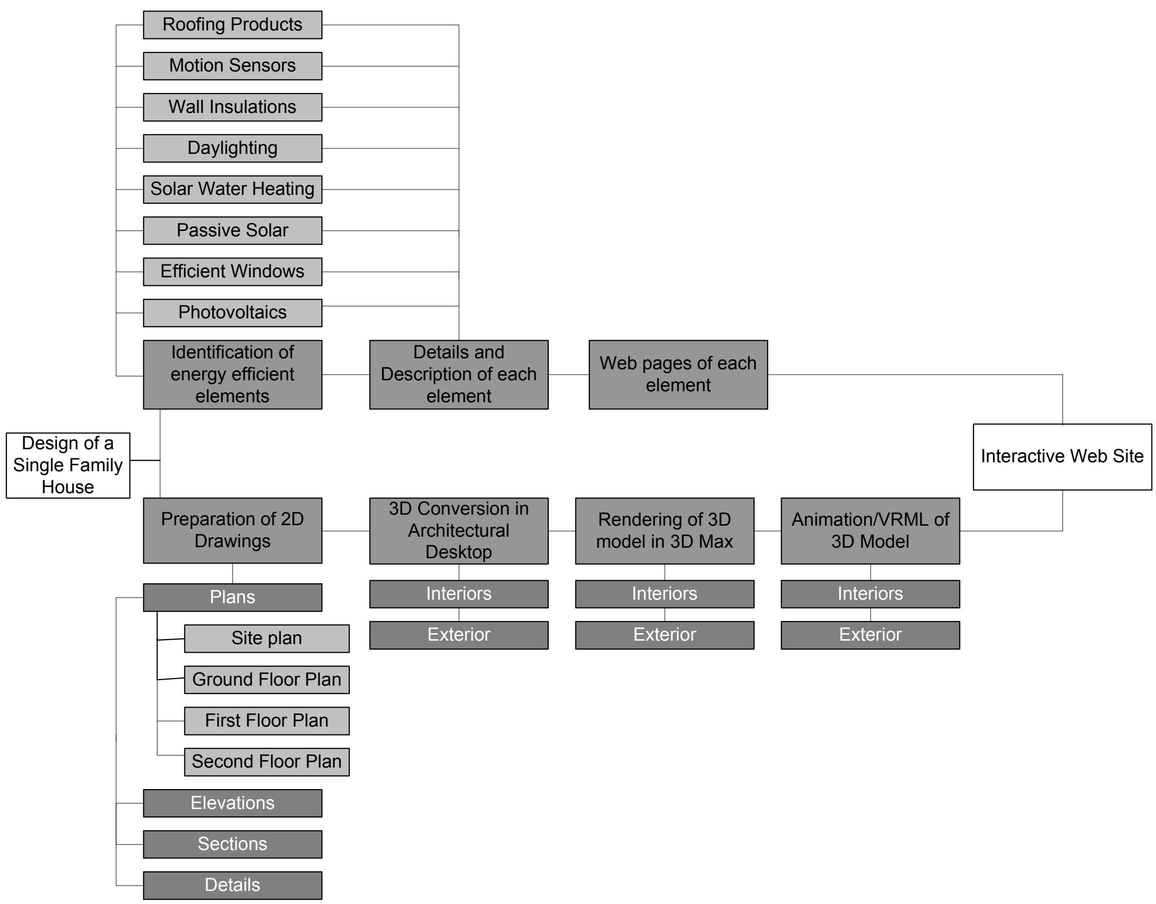

Figure 1: Work Flow Diagram

2. Development of Drawings: The various 2D architectural drawings namely plans, sections and elevations were prepared using AutoCAD® 2005 (Figure 2).

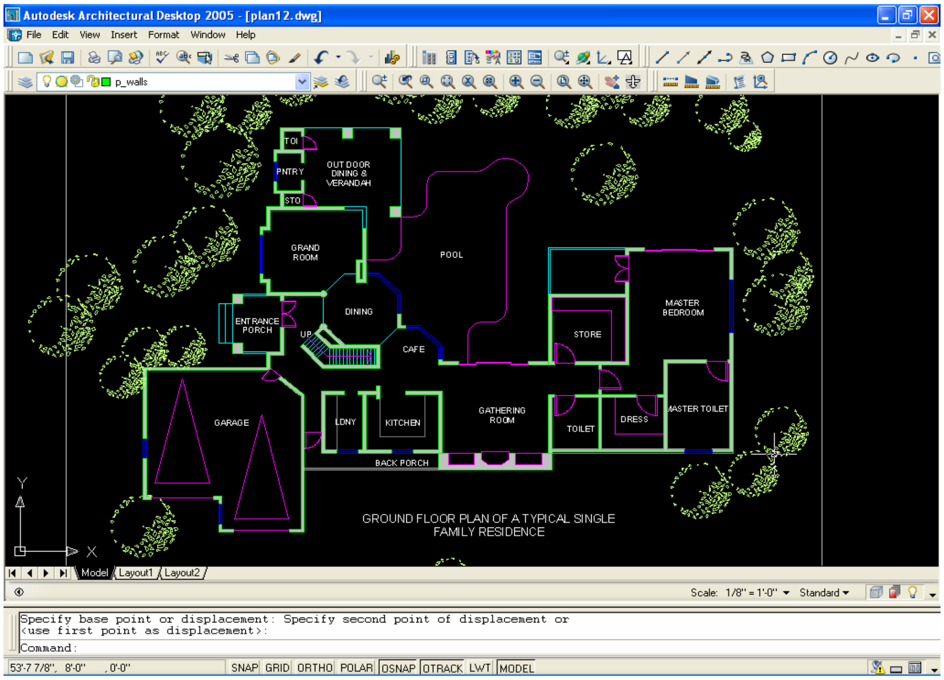

Figure 2: 2D drawing of the house

3. Development of a 3D Model: The next step was to develop a 3D model of the design using AutoCAD® Architectural Desktop 2005 (Figure 3).

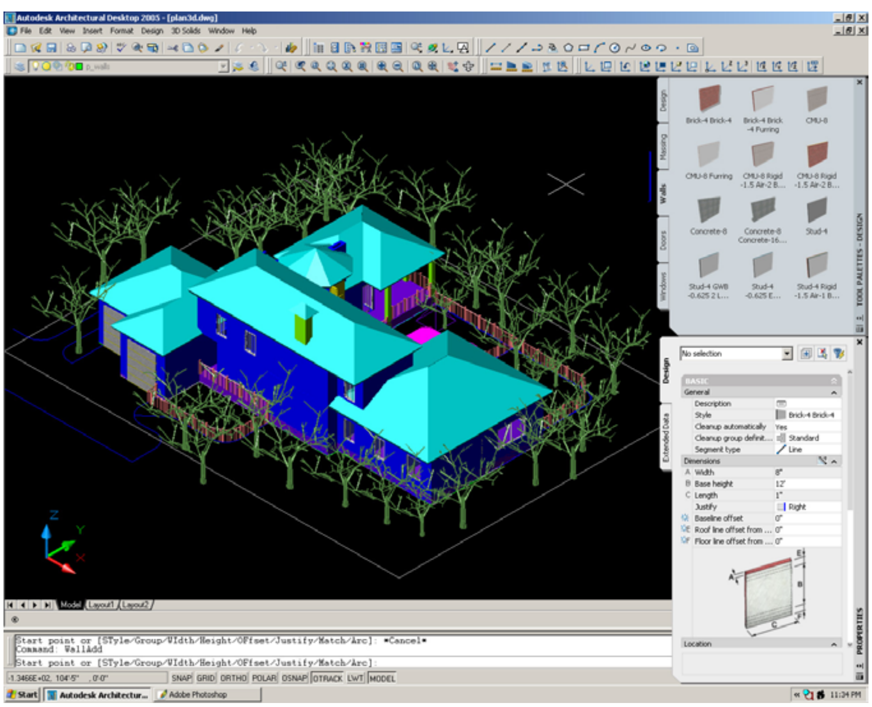

Figure 3: 3D model of the house

4. Development of an Animated Walkthrough: The next step was to develop an animated walkthrough of the house with a focus on various all the energy conscious elements of the building using 3DS MAX (Figure 4 & Figure 5).

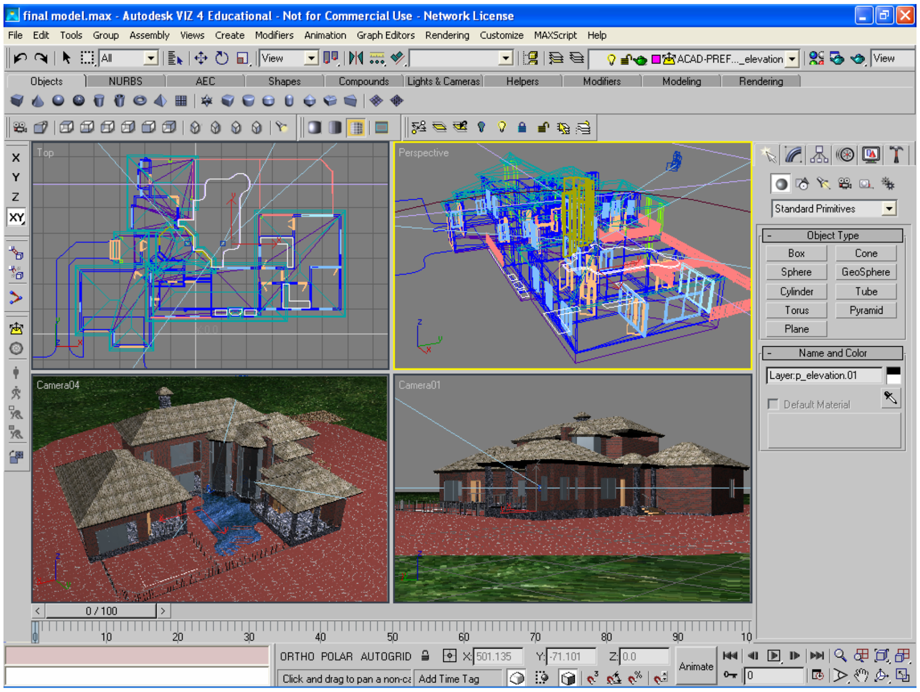

Figure 4: Walk through of the house using 3D MAX

Figure 5: Snap shot of walk through

5. Analysis and Description of Elements: A brief analysis and description of each element was carried out to explain the concepts, energy benefits, technical details etc. of individual elements.

6. Development of the Website: The final step was to develop an interactive web based model integrating the 3D model, animation, and the description using a combination of Flash MX, Dreamweaver MX and HTML (Figure 6).

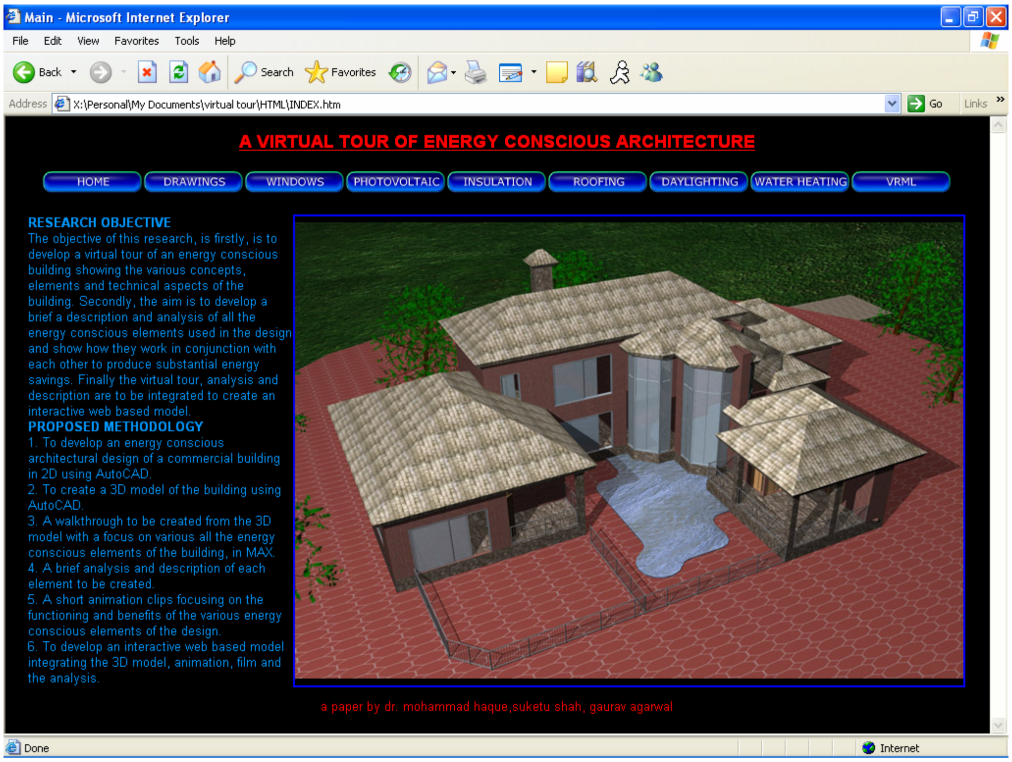

Figure 6: Screen shot of Website

7. The tour would include and focus on the following aspects of an energy conscious architectural design:

a) Energy Efficient Windows: Advances in window and glass technology have resulted in greater energy efficiency, while yielding better quality of indoor environment through natural lighting. The ultraviolet light-filtering glazings have led to reduce energy demands (Figure 7).

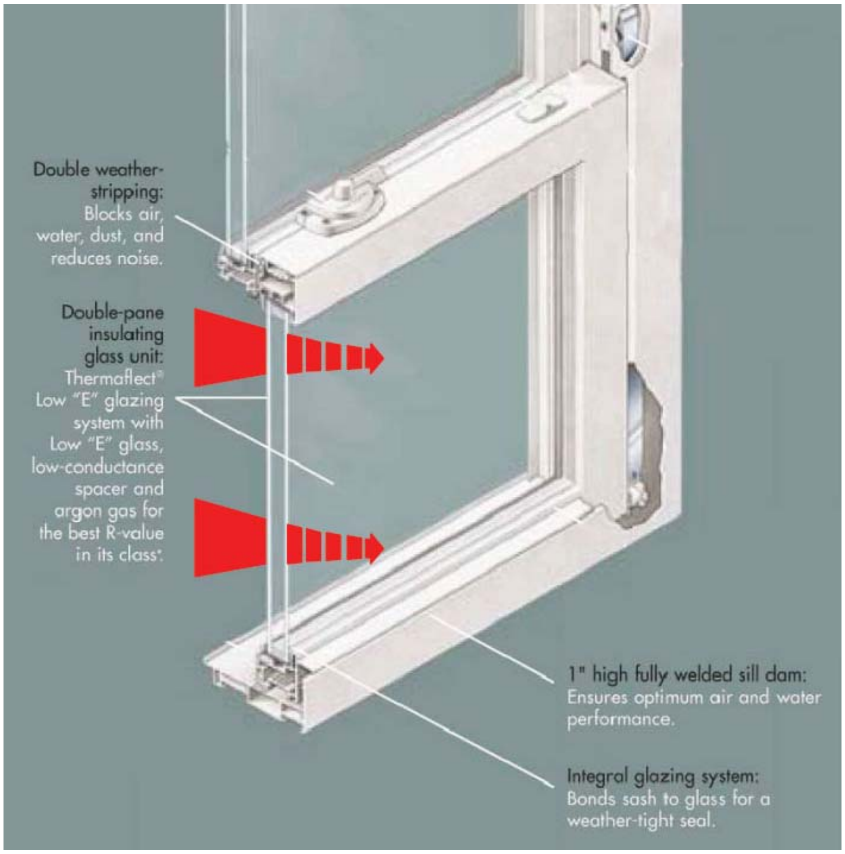

Figure 7: Double-glazed window with low solar gain

b) Passive Solar Design: Passive solar design includes a broad range of building design strategies. A passive solar building design allows sunlight, heat and air flow into building only when needed, and only in amounts necessary to raise the occupants' comfort level. A passive solar design successfully integrates and balances the use of daylighting, an efficient building envelope, and the use of energy efficient mechanical and electrical equipment to create a comfortable, healthy and energy efficient indoor environment.

c) Photovoltaic: Photovoltaic cells create electrical current from sunlight. The technology has advanced to the point where certain building components contain photovoltaic cells integrally. Photovoltaic cell integrated roofing panels can be purchased and installed in a manner similar to those made out of sheet metal, while taking benefit of the ambient sunlight to generate electricity (Figure 8).

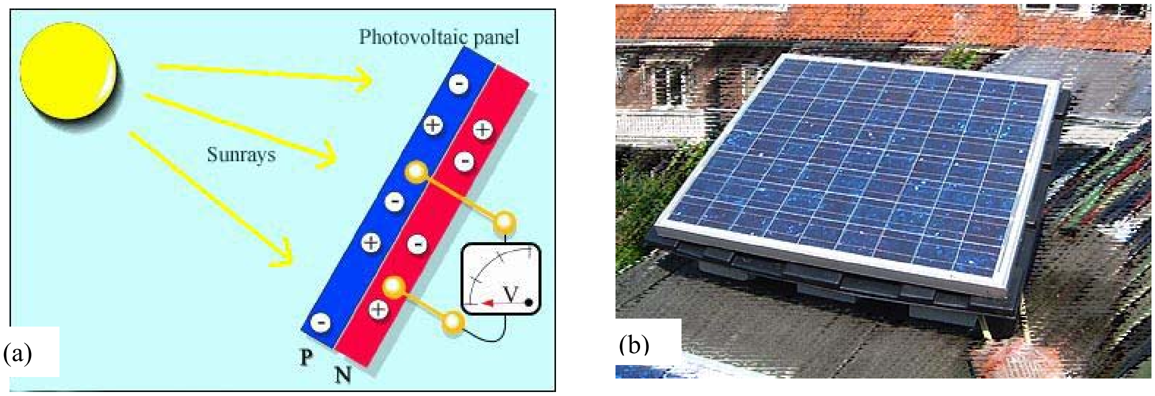

Figure 8 (a) Function of photovoltaic; (b) Image of a photovoltaic cell installation on a rooftop of a residential unit.

d) Solar Water Heating: Solar water heating is another passive solar design that uses available sunlight to increase a building's energy efficiency. Solar water heaters use the sun's energy to heat water for building occupants' use. Solar water heaters are most often installed on roofs of buildings. They are used in line with electric or gas water heaters. The basic design intent is to pre-heat water, before it enters the electric or gas hot water heater. Water is drawn from the solar hot water heater into the gas or electric hot water heater to replenish the water drawn by building occupants. The system reduces energy consumption by making the utility powered hot water heater in essence a storage facility for hot water heated by the solar system.

e) Roofing Products: The biggest recent advance in roofing products technology came with the advent of the radiant barrier. This physical layer in the roofing system acts to reflect sunlight back out of the roofing system before the light can be trapped and converted into heat inside the building envelope. The systems are simple to install, and only add slightly to initial building costs.

f) Motion Sensors: There has been a leaning towards the installation of motion sensors that would detect the presence of people. The development of these intelligent motion sensors would switch on and off the lights depending upon the occupancy. Thus theses equipments can offer sizeable energy savings over the life cycle of the building even though their initial installation costs are higher.

g) Wall Insulations: Advancement in material technologies has made it possible to install new insulating materials in the walls that have high R values and are more environmentally friendly.

h) Daylighting: Daylighting is the architectural or building design feature that allows natural light to be brought into interior spaces, and distributed adequately within the interior space. Successful daylighting of interior spaces reduces the need for electrical light sources, reducing energy demands and costs, while also reducing the heat generated by electrical light sources. This reduction in heat generation can allow for smaller air conditioning systems, saving further energy consumption costs. Numerous design features can be included in the interior of the building to allow for natural daylight illumination. The most common feature is fenestration, or window apertures, properly spaced and located within the exterior walls to avoid direct sunlight, while allowing indirect illumination. A common feature used to distribute indirect sunlight is the light shelf. This passive architectural device is actually a shelf structure, placed well above eye level, but below a glazed opening in a wall, and is used to reflect light above the height of the eye up onto the ceiling of the room, allowing natural light to penetrate deeper into the interior space.

Concluding Remarks

The effort of this research paper was to showcase the energy saving elements used in an energy conscious architectural design using 3D models and animations. Considering the interest of youths in computer games these days, the use of a 3-D computer animation model will develop a lot of interest amongst them, and will motivate them to try to better understand and retain important aspects of energy conscious in architectural design. This would also help to generate awareness among common people about energy conscious design, as the web interface is easily accessible and user friendly. The models and animations can act as an excellent teaching tool to explain the various concepts integral to an energy conscious design, as the instructor would present the entire scheme in a virtual world so that the students can understand the concepts with more clarity and ease.

The research has implications in the business world too as the model could be an effective tool to explain potential clients the benefits of an energy conscious design. The model could help to convince potential client/user to increase their initial expenditure outlay in return for future savings on recurring energy costs, thus benefiting the user and the environment in the long run.

All the techniques that were used in this research employed a generic programming architecture, which was discipline independent and could be adapted to any other similar domain. These visualization techniques can be valuable aids not only in teaching in the classroom but also an effective self-directed tool for open learning via the web.

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