VIEW – A Virtual Interactive Web-based Learning Environment for Engineering

Priya T. Goeser, Wayne M. Johnson, Felix G. Hamza-Lup and Dirk Schaefer

EXTENDED ABSTRACT

Introduction

Engineering programs throughout the country face similar challenges: student learning, student success and retention [1]-[4]. In addition, more and more adults participate in online education and distance learning programs for various reasons and the demand for such programs is growing [5]. In order to address these issues, educators have developed and implemented several pedagogical approaches to teaching and learning including project-based learning, student-centered learning, and computer-based learning, etc., that are well grounded in the scholarship of education and instructional techniques [6]. Furthermore, more and more computer-aided and web-based educational technologies are used in the classroom. This includes so-called Virtual Learning Environments (VLEs) [7]. One example of such a web-based Virtual Learning Environment is Virtual Interactive Engineering on the Web (VIEW), which is a set of 3D web-based laboratories and modules based on the Extensible 3D (X3D) standard. X3D can be used to develop applications that enhance student learning across a broad range of applications including computer-aided design (CAD), visual simulation, medical visualization, and geographic information system (GIS).

The laboratories and modules in VIEW provide student-centered, interactive, and engaging learning environments and are currently mainly used for freshmen and sophomore engineering students at Armstrong Atlantic State University (AASU). In general, VIEW may be employed both on its own and/or as a complementary supplement to so-called remote laboratories, that is, physical laboratory experiments that are remotely controlled through the internet and can be taken by distance learning students any time and from anywhere with an internet connection [8]-[10].

In the following sections the authors present a brief background on the Extensible 3D standard, an overview of the VIEW project, a summary of related assessment tools, lessons learned and concluding remarks as well as an outline of future work and associated research issues.

Background: Extensible 3D

The technological backbone of VIEW is the Extensible 3D (X3D) standard. X3D is a scalable and open software standard for defining and communicating real-time, interactive 3D content for visual effects and behavioral modeling [11]. It can be used across hardware devices and in a broad range of applications including interactive simulations used for engineering education. X3D provides both the XML-encoding and the Scene Authoring Interface (SAI) to enable both Web and non-Web applications to incorporate real-time 3D data, presentations and controls into non-3D content. As a successor to the Virtual Reality Modeling Language (VRML), X3D is a mature and refined standard [12]. Some additional features of X3D include [13],[14]:

- Compatible with the next generation of graphics files, e.g. Scalable Vector Graphics.
- Open source (no licensing fees).
• Has been officially incorporated within the MPEG-4 multimedia standard.
• XML support makes it easy to expose 3D data to Web Services and distributed applications.
• 3D objects can be manipulated in C or C++, as well as in Java.

Overview of VIEW
The main objective of this work is to develop and evaluate a 3D virtual, interactive, student-centered, framework of web-based modules using X3D, dedicated to the improvement of teaching and learning, recruitment and retention in the engineering curriculum. In order to meet this objective, project Virtual Interactive Engineering on the Web (VIEW) was first developed and deployed in Fall 2008 with the following specific teaching and learning aims:

1. Increase student exposure and understanding of how mechanisms interact to convey motion in various devices and systems.
2. Improve student understanding of engineering material property characteristics and performance.
3. Improve student spatial visualization skills as it pertains to material property structures and 3D parts used in design.
4. Develop real-world case studies for the application of graphical user interfaces and programming skills in various Computer Science courses.

Currently, there are two phases of VIEW that have been implemented based on the above aims. The following sections present a summary of these phases and the assessment results based on them. Further details of VIEW can be obtained from the following URL: http://cs.armstrong.edu/felix/projects/VIEW/.

The Virtual Tensile Testing Laboratory
The initial phase of this project was the development of a Virtual Tensile Testing Laboratory (VTTL) used as a supplement in the course: Introduction to Engineering Materials [15], [16]. This is a 3-credit lecture course taken by sophomores in mechanical, civil and electrical engineering. The course covers the fundamentals of materials processing, materials structure, material properties and testing, and materials performance in various engineering applications. Students often view this course as a collection of abstract concepts that are difficult to understand and relate to practical applications. This contributes to the challenges to maintain a high level of interest, enthusiasm and information retention among the students. The main objective of the VTTL is to introduce students to the testing techniques required to evaluate certain mechanical properties of materials such as the elastic modulus, yield strength, ultimate tensile strength, ductility, toughness and fracture strength.

It is noted that while hands-on laboratories are an essential part of engineering education, such laboratories are not always available due to the lack of space, high costs and time constraints. An emerging trend to address this issue is to develop web-based virtual laboratories to replace and/or supplement physical laboratories [17]-[21]. In addition, such web-based virtual laboratories can be used in concert with remotely controlled physical laboratory experiments that are anticipated to close one of the major gaps in distance learning education.
The virtual tensile testing laboratory (VTTL) consists of a realistic and detailed 3D CAD model of a tensile testing machine created using SolidWorks [22] and imported into the virtual scene using X3D. The graphical user interface for the laboratory features HTML controls, a virtual 3D scene, and a graph/display panel. The HTML controls include clickable images allowing the user to choose a material sample and buttons for starting the experiment, examining the current sample in predefined views and downloading experimental data. This data is then analyzed by the students to determine relevant material properties.

The student surveys for VTTL showed that 83% or more students strongly agreed or agreed that the laboratory helped them to better understand the use of the stress-strain curve to determine mechanical properties of materials, an important concept studied in the course. A comparison of grades (based on a particular exam problem) between the students who took the course prior to the use of VTTL and those who took it with access to VTTL showed an increase in the number of students (% of students enrolled) who received a 75% or higher grade on this particular problem, demonstrating a better understanding of these concepts.

**The Mechanical Dissection Module**

Mechanical dissection is an engineering activity that can satisfy a student’s curiosity of how and why the components of given devices can convey specific motions to achieve a desired result [23]. Hence, several university engineering programs have developed mechanical dissection laboratories. However, such laboratories are not always feasible due to the lack of space, personnel, time and high costs. This issue is now being addressed through the use of multi-media technology to replace/supplement physical laboratories [24], [25]. Virtual dissection/assembly implemented in VIEW would only require the use of existing computer laboratories. This module is used as a supplement in the course: Introduction to Engineering.

Introduction to Engineering (ENGR1100) is a 3-credit hour freshmen engineering course, in which students are introduced to the engineering process from problem formulation to the evolution of creative design. The objectives of this course are to excite students about engineering, cultivate problem-solving skills, encourage creativity, cultivate professionalism and emphasize the importance of communication skills. One approach to meeting these objectives is through the use of mechanical dissection/assembly activities.

The mechanical dissection module in VIEW consists of a 3D CAD model of a mechanical power toothbrush modified using SolidWorks and imported into the virtual scene of the simulator using X3D. The models were originally created as part of the Cyber-Infrastructure-Based Engineering Repositories for Undergraduates (CIBER-U) project [26]. The graphical user interface of the simulator features HTML controls, a virtual 3D scene, and a control panel with a timer and scoring scheme. The scoring scheme and timer were used to emulate a gaming scenario as much evidence exists to support the effectiveness of digital game-based, interactive, student-learning environments [27]-[30]. The module was implemented as team projects in ENGR1100 in Spring 2009 and Fall 2009. The projects consisted of four phases, which were based on the engineering design process also introduced in this course.

Similar survey results for the mechanical dissection module show that 95% or more of the students strongly agreed or agreed that the 3D models helped them to better visualize and
understand the relationship between mechanical dissection and design. The ‘computer game’ scenario used in the simulator was also received well by majority of the students. In addition to the surveys, the design schematics and descriptions submitted after every phase were evaluated to assess the effectiveness of the module on student learning. It was observed that the students developed a good understanding of the functions and roles of all the parts in the final product, and were extremely creative in their designs with an emphasis on crucial details important in such a product.

Concluding Remarks and Future Work
This paper presents a summary of the recent developments in the first two phases of project VIEW. The results of student surveys, comments and student performance show that VIEW has been beneficial to and well received by students. These phases will continue to be used and assessed in subsequent semesters.

This work also lays the foundation for the development of additional virtual laboratories/teaching modules for these and other courses. For example, the development of the 3D CAD models for this project will also be presented as an application case study in the course Engineering Graphics (ENGR 1170), in which students learn SolidWorks, and a modified mechanical dissection module can be developed for the course Creative Decisions and Design (ENGR 2110). New modules can also be developed for Engineering Graphics to help students visualize the spatial rotations of various geometrical solids. Other virtual laboratories used to evaluate material properties such as the flexural bending test, the Charpy impact testing, etc. can also be developed to supplement the Introduction to Engineering Materials (ENGR2000) and other courses. Based on assessment results and subsequent improvements to VIEW, it is proposed that these modules will be freely available to the general engineering education community.

References


[20] Rutgers University and University of Illinois at Urbana Champaign; The Instructional Remote Laboratory Consortium; http://mechanical.rutgers.edu/irle.

[21] Karweit, M. A. A Virtual Engineering Laboratory Course; http://www.jhu.edu/virtlab/virtlab.html

[22] A 3D Mechanical Design and 3D CAD Software; www.solidworks.com


