INTERACTIVE WEB-BASED LEARNING USING INTERACTIVE MULTIMEDIA SIMULATIONS

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Abstract — *In this paper, interactive animations are used to enhance presentation of difficult engineering topics. Teaching pedagogies and modern communication technologies are integrated to enhance learning and retention. Selections of topics from two courses, Statics and Geotechnical engineering, are used to illustrate the use of interactive animations, graphics and text to satisfy various learning styles. The simulations were developed using various royalty-free commercial software such as Authorware.*

Index Terms ¾ *Engineering education, engineering mechanics, statics, geotechnical, interactive multimedia.*

INTRODUCTION

The World Wide Web, simply the Web, is increasingly used to deliver educational resources. These resources vary significantly in quality and usage. At the basic level, the developer may distribute text-based materials with or without some graphics or artwork. At the top level, the developer may distribute interactive content with dynamic graphics or animations with or without streaming audio and video. The range of media types (text, images, interactive and non-interactive animations, audio and digital videos) that is possible using the Web can lead to its misuse and abuse for the delivery of educational resources.

The question that arises for educators is "How can we best enhance education within the distributed environment of the Web?" Two of the top considerations are: who are the audience for whom the knowledge is created and how can we capture their interests in learning? We are surrounded with a host of visual media – TV, computer games, video games, etc. – and obtain much of our information from them. Research has shown [1] that hearing and seeing lead to 50% knowledge retention compared with 20% for hearing only. It appears that educational resources should be created that contain significant visual content. But, what visual content and how can this be done for the Web? Visual content can be an image or images, line art, digital video, interactive animations and non-interactive animations. The developer has to decide carefully which form of visual content is best for a given piece of educational resources. Certain types of educational materials, especially certain engineering concepts that students find difficult to understand, are possible candidates for enhancement by using the power of the Web to deliver multiple media format. The visual content can be created by selective use of modern communication technologies such as Macromedia's Flash MX, Authorware and Director.

The overall goal of developing Web-based educational resources should be to maximize the Web strengths (anytime-anyplace, visual and audio content) and to minimize its weaknesses (impersonal, unsuitability for reading large amount of text, non-uniformity method of delivery, for example slow modem) .

The intention of this paper is to illustrate and discuss how selective use of modern communication technologies (interactive

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animations) can be used to enhance the presentation of difficult topics in engineering education. Illustrations of topics within two engineering subjects, Statics and Geotechnical Engineering, are used to exemplify the use of interactive animations.

KEY PEDAGOGIES AND TECHNOLOGIES

In developing web-based interactive learning modules, the author used the following pedagogies and technologies

- Gains student's attention by presenting a practical situation where the material to be learned applies to their everyday life.
- Informs students of the learning outcomes
- Presents the course material in a way that connects the learner with the material to be learned.
- Content presented using interactive animations, graphics, text and sound.
- Students learns by doing
- Provide immediate feedback
- Track performance of students for their own assessment and assessment by instructors.
- Students learn at their own paces.
- Assessment of prerequisite knowledge.
- Reinforcement of knowledge through summaries of key points at selected points in the course content
- Measure short term knowledge assessment using quizzes
- Develop problem-solving skills using interactive problem-solution exercises.

ENGINEERING MECHANICS – STATICS

In most higher education institutions in engineering, Statics is the first "real" engineering course that a student takes. Many other courses in engineering curricula require Statics as a prerequisite course. Students often view Statics as a 'weed-out' course, whereby their educational career in engineering depends on success on this course. Frequently, students entering the course are either not well prepared in the fundamentals such as physics and mathematics or have forgotten them. Instructors either spend a small amount of time reviewing prerequisite materials or prepare handouts on them or refer students to suitable materials.

In many schools in the US, one of several Statics textbooks available commercially, is recommended for use in the course. Nearly, all these textbooks follow the same format and order of presentation of the content.

In the web-based course developed by the author, review materials and evaluation of the students' knowledge in the prerequisite material are tightly integrated into a flexible course structure (Figure 1).

The course structure consists of six groups of modules.

(1) Readiness Assessment
(2) Individual topics - forces, moment, etc., required for the use of the equilibrium equations
(3) Equilibrium equations
(4) Applications of equilibrium equations – beams, trusses, frames, static friction, cables.
(5) Extraneous topics that do not deal with forces and moments such as second moment of area and centroid.
(6) Final examination

Within a group, a student can explore any of its modules. Examinations are built into each group to evaluate students' performances. There are two milestones that are built into the courseware as default. The first milestone is the prerequisite material. A student must pass a web-based examination on the prerequisite knowledge before proceeding to the course material. The examination can be taken any time a student wishes to do so. If a student passes the examination, a password is automatically issued to allow him/her access to the next course level. If a student scores between 70 and 79%, he or she can retake the examination. If a student scores below 70% he/she must see the instructor for advice. The instructor can change passing scores. Each student has the same type of questions but with parameters that are randomly generated.

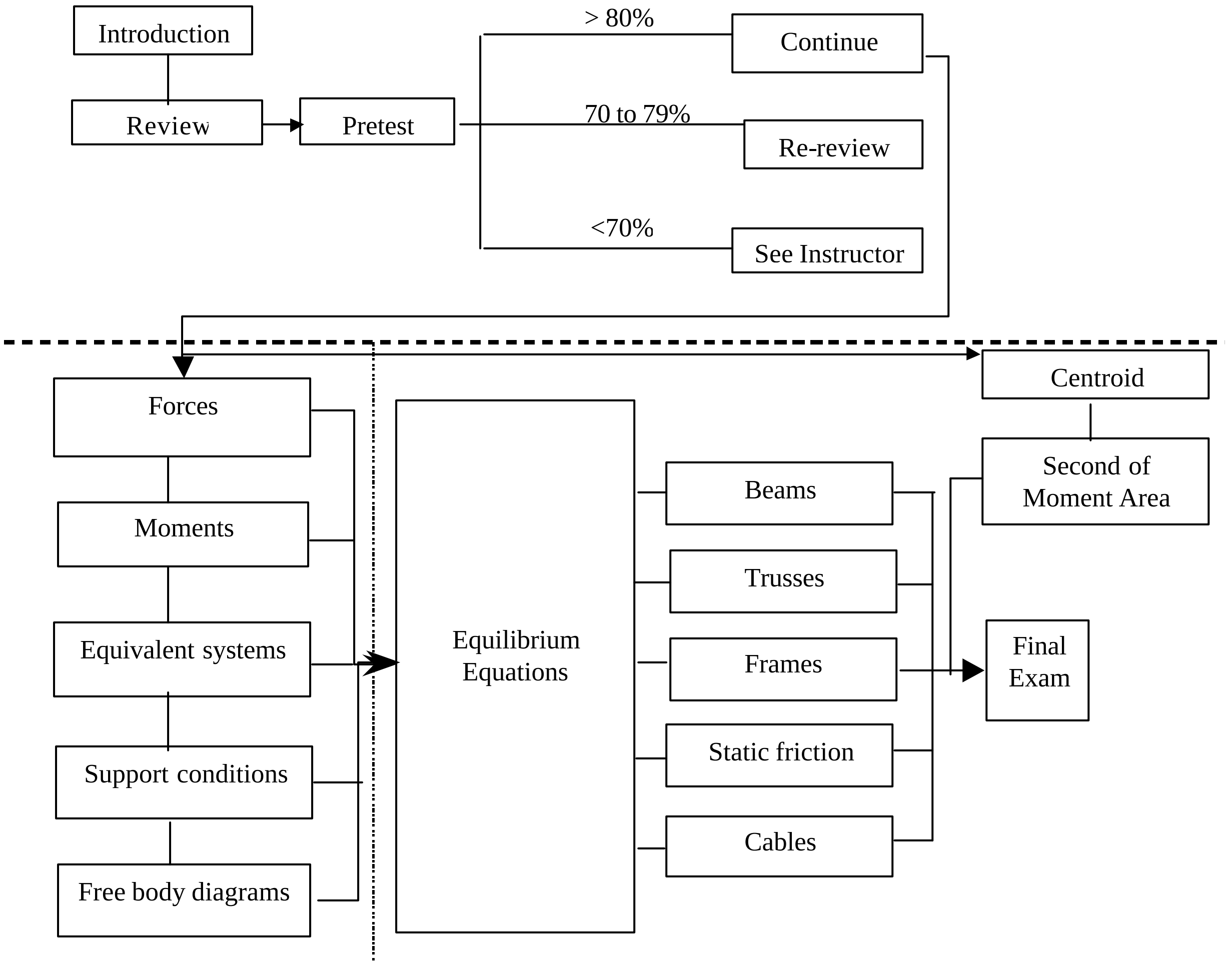

FIGURE 1
STRUCTURE OF WEB-BASED STATICS COURSE.

A student retaking the examination has a different set of examination questions. The second milestone is placed on equilibrium equations. The essence of Statics is the application of Newton's second law when the acceleration on a rigid body is zero. The core of an undergraduate course in Statics is then an understanding of the equilibrium equations and their use in problem solving. But before a student can understand the equilibrium equations, he/she must understand the concepts of forces, moments, equivalent systems, support conditions, and free body diagrams. Therefore, before a student proceeds to equilibrium equations he/she must demonstrate mastery of forces, moments, equivalent systems support conditions, and free body diagrams. An instructor can remove these milestones.

Each module consists of instructional materials on basic concepts, applications, examples, and evaluations. The review material consists of the principles in algebra, geometry, relevant trigonometry, vectors, physics and calculus.

The course materials are presented using text-based material and interactive animations to cater for the verbal, visual, active and passive learners [2]. An example of three frames of an interactive animation of finding the components of a force in two dimensions is shown in Figure 2.

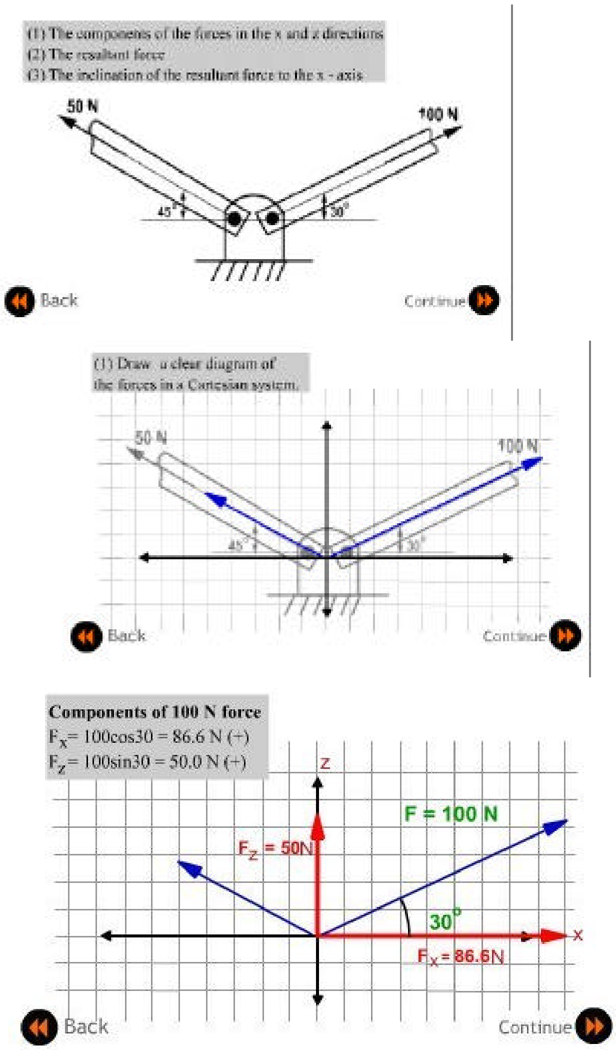

FIGURE 2
THREE FRAMES OF THE INTERACTIVE ANIMATION FOR DETERMINING COMPONENTS OF FORCES

One of the difficulties that students face in Statics is the drawing of a free body diagram. In the courseware developed by the author, interactive animations are used to enhance learning of free body diagrams. In figure 3, the student uses a mouse to drag members from a structure to reveal the forces that must act for equilibrium. The student does so at his/her own pace.

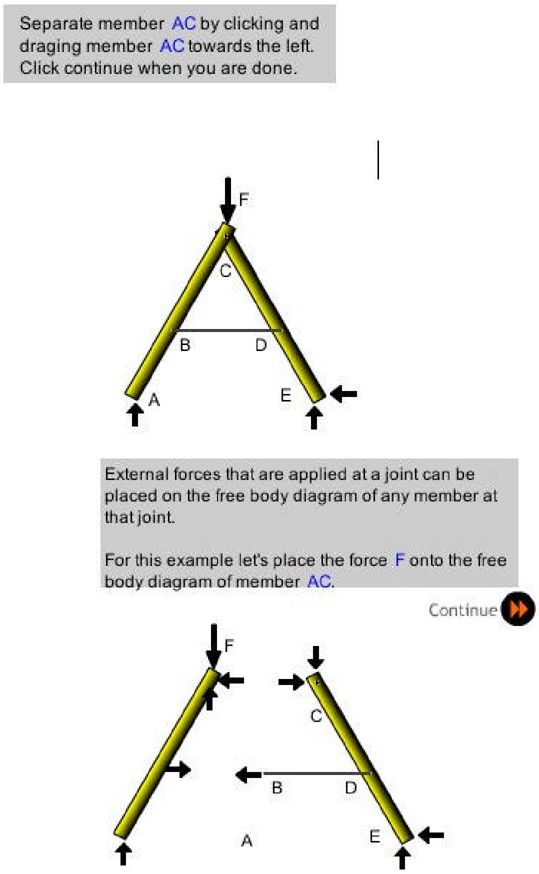

FIGURE 3
TWO FRAMES FROM THE INTERACTIVE ANIMATION OF THE FRAMES MODULE

GEOTECHNICAL ENGINEERING EXAMPLE -INTERACTIVE CRITICAL STATE CONCEPT

Geotechnical engineering is a course of study that deals with the properties of soils for use in construction, in the design of foundations for buildings, dams, tunnels and similar systems, and in evaluating and designing safe slopes and retaining structures. Geotechnical engineering is one of the courses required in undergraduate curriculum in Civil Engineering. An important topic in geotechnical engineering is the concept of critical state – a state of constant stress and constant volume – that has been recognized [3-5] as a characteristic of soil. The ideas of critical state was further developed [5,6] into a framework or model that provided an understanding of the mechanical behavior of soils that are of the greatest importance to geotechnical engineers. However, the critical state model is not widely taught to undergraduates. The author has not done any comprehensive survey for the reason or reasons for not introducing the critical state model to undergraduates. One reason that was expressed by some faculty is the complexity of the various mechanics elements such as yielding and plasticity that are embodied in the critical state model. We may ask, can modern communication technologies be used to enhance the understanding of these mechanics elements to enable students to understand the critical state model? The author [7,8] developed a multimedia interactive courseware on the critical state model with the following learning goals.

- To describe soil yielding and simple plasticity concepts necessary for the understanding of the critical state model.
- To estimate failure stresses under drained and undrained conditions.
- To estimate the volume changes under drained condition and the changes in excess pore water pressure under undrained condition.
- To estimate stress-strain behavior for loading conditions below failure.
- To evaluate possible soil stress and strain states if the loadings on a geotechnical system were to change from those anticipated.

It is assumed in the courseware that the students have the prerequisite knowledge such as stress and strain invariants. However, this is available to the students though links to other modules that teaches them this prerequisite knowledge. Interactive animations and mathematical solutions are used in concert to improve learning and retention. Two screen shots (Figures 4 and 5) illustrate the kind of self-paced interactivity developed. As the soil is gradually stressed, in this case isotropically, the yield surface progressively expands until the maximum stress is attained (Figure 4). The soil is then unloaded to a desired value. If after unloading, the soil is then sheared under drained triaxial conditions, the effective stress path (q/p′) will have a slope of 3; q is the deviatoric stress and p′ is the mean effective stress. Projection geometry is used to demonstrate the initial yield point and the failure point (Figure 5).

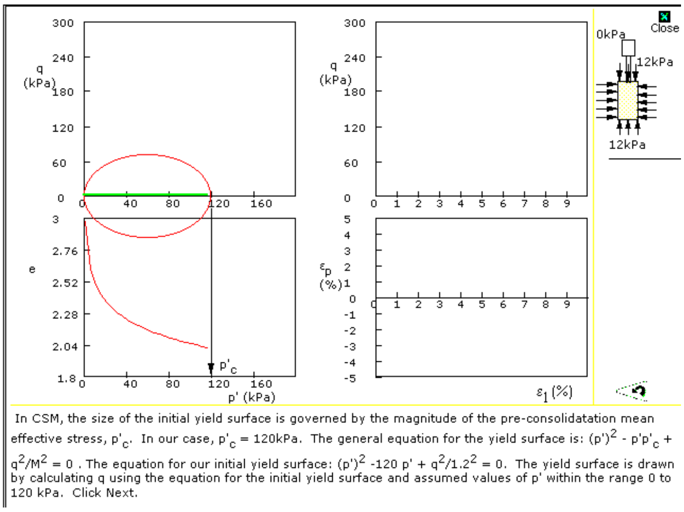

FIGURE 4
INITIAL YIELD SURFACE OF THE CRITICAL STATE MODEL

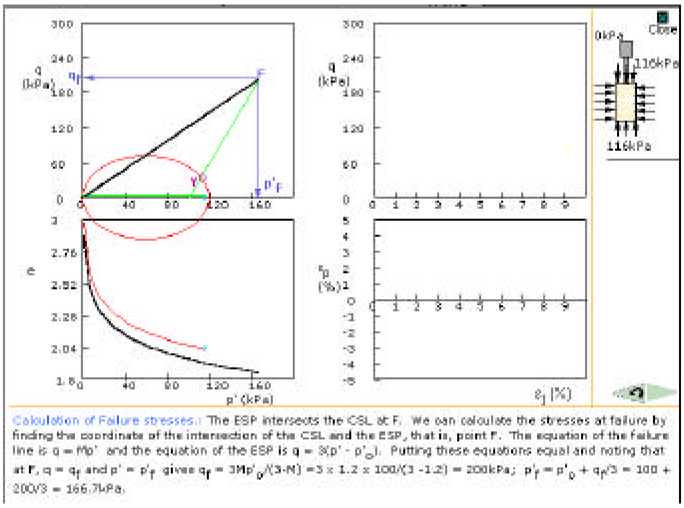

FIGURE 5
FAILURE STRESSES OF A DRAINED TRIAXIAL TEST FROM THE CRITICAL STATE MODEL

The method of calculating the initial yield and failure stresses, and the void ratios at initial yield and at failure are presented (Figure 6). If a small increment of stress is applied beyond initial yield, the yield surface expands and plastic strains develop.

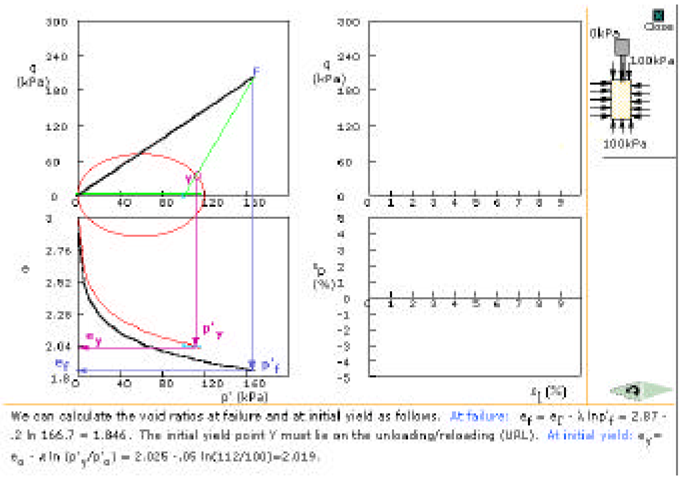

FIGURE 6
ILLUSTRATION AND CALCULATION OF YIELD AND FAILURE VOID RATIOS IN A DRAINED TRIAXIAL TEST FROM THE CRITICAL STATE MODEL

The elastic and plastic volumetric strains (shown as void ratio changes) resulting from a small increment of stress is depicted in Figure 7. The module continues by showing how to determine the shear strains and how failure is achieved. The stress-strain diagrams following each loading increment are animated.

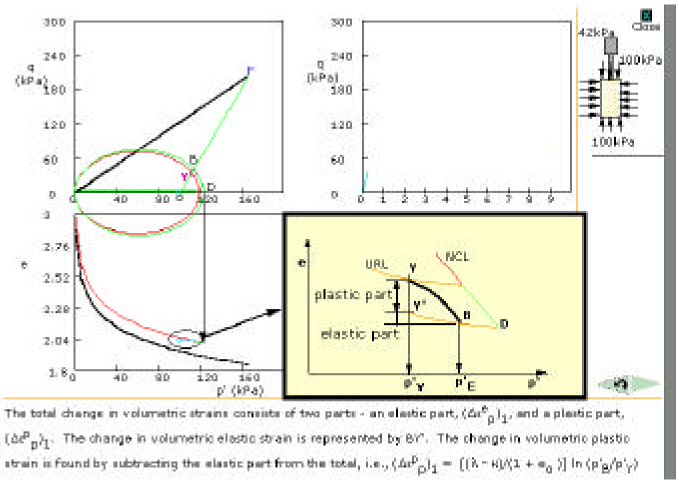

FIGURE 7
ILLUSTRATION OF ELASTIC AND PLASTIC VOLUMETRIC (VOID RATIO) CHANGES IN A DRAINED TRIAXIAL TEST FROM THE CRITICAL STATE MODEL

A summary of key points at strategic locations in the courseware reinforces the essential knowledge. The courseware allows a student to explore "what-if" situations. For example, a student can use a set of soil parameters and let the critical state model predicts the stress-strain behavior under drained conditions. The student can use the same or different parameters to investigate undrained behavior. If experimental results are available, the student can compare the predictions with the measured results.

ACKNOWLEDGEMENTS

The work described here has been funded by grants DUE-9950906 and DUE-0121691 from the Division of Undergraduate Education, United States National Science Foundation.

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