JAVA Simulation based Soil Mechanics Laboratory Course Studio

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Abstract

In the field of civil/geotechnical engineering, students conduct a variety of soil tests to fulfill undergraduate soil mechanics course requirement. There is a range of problems in soil laboratory instruction, such as, some students not getting hands on experience of conducting tests because of inadequate number of apparatus, time constraints and inability in exciting students to seriously conduct the experiments. However when these laboratory soil tests are simulated with multimedia interaction and visualization techniques, the student's conceptual understanding of soil mechanics is enhanced. The methodology presented in this paper is based on presenting students with simulation of laboratory soil tests, which creates an individualized, interactive and guided learning environment. The main elements of this approach are: a means of assimilating the students' interactive learning knowledge and behavior (user model), representation of the instructor's guidance and assessment knowledge (tutor model), utilization of motivational techniques such as multimedia, animation (visual model) and simulated laboratory test model (simulation model). As an example, the presented paper provides the learning environment to understand soil characteristics such as grain size distribution. The approach adopted in this research is that of intelligent interactive learning environment, which is developed, using Java simulation. This contains basic interrelated definitions (concepts), various graphic presentation of soil characteristics, test procedures and Java simulation of dynamic laboratory testing. Although the presented approach is being applied to understand basic soil mechanics, it employs a generic architecture, which is discipline independent and can be adapted to any other similar domain which will certainly promote and enhance students' understanding.

I. Introduction

In a world in which technology is changing rapidly, students need to be able to think creatively and solve problems and acquire higher order thinking skills. Particularly technological students are to be competitive in the years to come where faculty needs to be able to provide their students with the cognitive strategies that will enable them to think critically, make decisions, and solve problems. According to Leutner[1], in traditional education, the teacher is responsible for the students' learning. Teachers typically lecture to students who take notes and then memorize and recall the material to perform well on examinations. This type of learning environment is not appropriate for engineering students who bring life skills and increased reasoning ability to the classroom. In such a situation, it may be appropriate for students to take responsibility for their own education. One method of transferring the responsibility from the teacher to the student is through guided tutoring and simulation. According to Menn's[2] evaluation of the impact of different instructional media on student retention of subject matter, it was found 90% of students remember if they do the experiments themselves even if only as a simulation. In other words, guided tutoring and computer simulations through labs that are properly designed and implemented could revolutionize technological education. The computer-based simulation software enables students to experiment interactively with the fundamental theories and apply them using electronic devices. It provides instant and reliable feedback. Thus, it gives students an opportunity to try out different options and evaluate their ideas for accuracy, almost instantly. The students presume that the laboratory equipment is not always accurate and reliable and they sometimes make the mistake of attributing their design errors to experimental errors. Thus, the simulation activity focuses mainly on the mental activity that takes place within the learner. The purpose of this research is to incorporate the geotechnical laboratory testings as guided tutor and use of computer simulation of the test to explore the impact on the problem-solving ability of students. These activities can be integrated into a traditional lecture-lab sequence. Although the importance of hands-on labs to the technological curriculum cannot be denied, Garcia[3] cited several advantages of computer simulations compared to laboratory activities. The presented soil laboratory studio which uses guided tutoring and simulations of tests prior to formal instruction and hands-on tests will alert the student to the overall nature of the soil tests. Like other interactive computer aided learning,[4,5,6] the proposed model allows the students to proceed at their own pace, motivated by a curiosity about " what happens" interactivity and " the need to know" test principles and procedures.

II. Proposed Approach

The main features of the proposed approach include virtual tour of soil testing, walkover survey of laboratory testing instruments, interactive instrument set-up and step-by-step laboratory testing procedure, computation and graphical presentation of test data and report writing. The two primary components of the proposed laboratory studio are:

- Guided Tutor Module: To create an intriguing guided learning environment of soil lab test and to generate interactive learning experiences that help students to form mental representations of procedures involving a soil test.
- Java Simulation based Lab Test Module: To develop cognitive architecture that simulates students' learning experience in soil testing.

Guided Tutor Module:

This module is designed to support the laboratory experiments within the context of normal teaching program. The material is aimed at supporting as a tutorial work bridging the gap between lab lectures and textbooks/lab manual. It introduces the students with the subject of the lab test, it's objective, it's reference to standards, such as ASTM and AASHO testing standards, apparatus/equipment, soil sample preparation, step-by-step test procedures, computations, graphical presentation of test results and conclusion on the test results. As an example, this paper illustrates the Mechanical Sieve Analysis for Soil for determining the particle size distribution. This test involves determining the relative amounts of particles within given size ranges in a soil mass. It uses a set of calibrated sieves, stacked in descending opening size, through which the soil is passed. The stack of sieves is mechanically vibrated for a fixed period of time. The weight of soil retained on each sieve is measured and converted into a percentage of the total soil sample. The amount of different particle sizes in a soil is then represented by a grain size distribution curve in a semi-logarithmic plot with the ordinates being the percentage by weight of particles smaller than the size given by the abscissa. From the shape of this curve, the soil can be classified as well-graded, gap-graded, and uniformly graded. The test is one of the most important soil tests for coarse grained soil classification and for determining their influence in soil density, permeability, shear strength and liquefaction potential.

The main screen of the guided tutor module consists of following:

- Test objective
- Reference of the State-of-the-art test Standards
- Apparatus/Equipment
- Soil sample preparation
- Test procedure
- Calculation and graphical representation
- Conclusion and Report

On selection of each topic, the model displays subjects, which are divided into short pages of information, which are stored and linked by menus and cross-references. Most of the material is text, but there are many simple diagrams and digital photographs. The "pop-up" windows are used to annotate diagrams and formulas. Also included are tutorial reference material and glossary of terms. The student can click forward and back buttons on the tutor button bar, to follow a guided tour through the reference pages. Figure 1 shows a sample screen development platform for the guided tutor model.

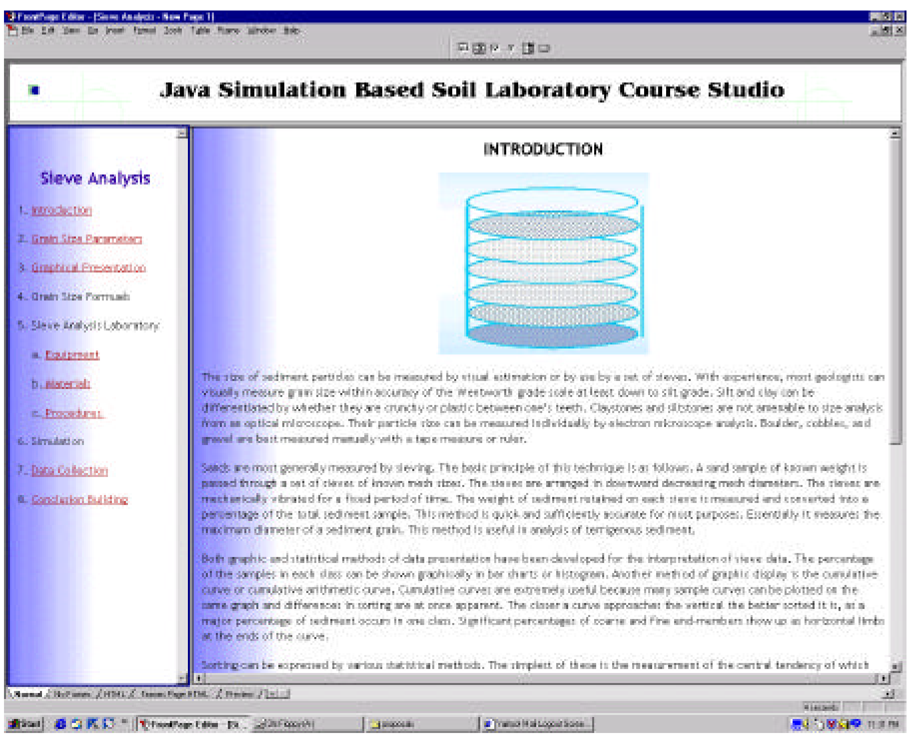

Figure 1. A sample screen development platform for the guided tutor model

Java Simulation based Lab Test Module:

The principal objective of the Java Simulation based Lab Test Module is to provide students with the opportunity to carry out soil test on-screen using an interactive virtual instrument set-ups, and step-by-step test procedures. This allows instructors to modify the different test simulation, to reflect their own requirements for technical contents and learning styles.

The main screen of the simulation model depicts a schematic series of known mesh sizes, mechanical vibrating shake table, a weighing scale, and a sample heap of soil. Figure 2 shows a sample model screen for the development of Java simulation model. In this model, the user will work interactively with all the objects, such as sieves, pan, vibrating shake table, and balance scale, etc., all of which are developed from actual digital photographs. During the interactive test procedure stage, the user is instructed to (1) weigh all the sieves, pan and soil sample, and (2) setup the sieves in stacks on the vibrating shake table by clicking and/or dragging operation.

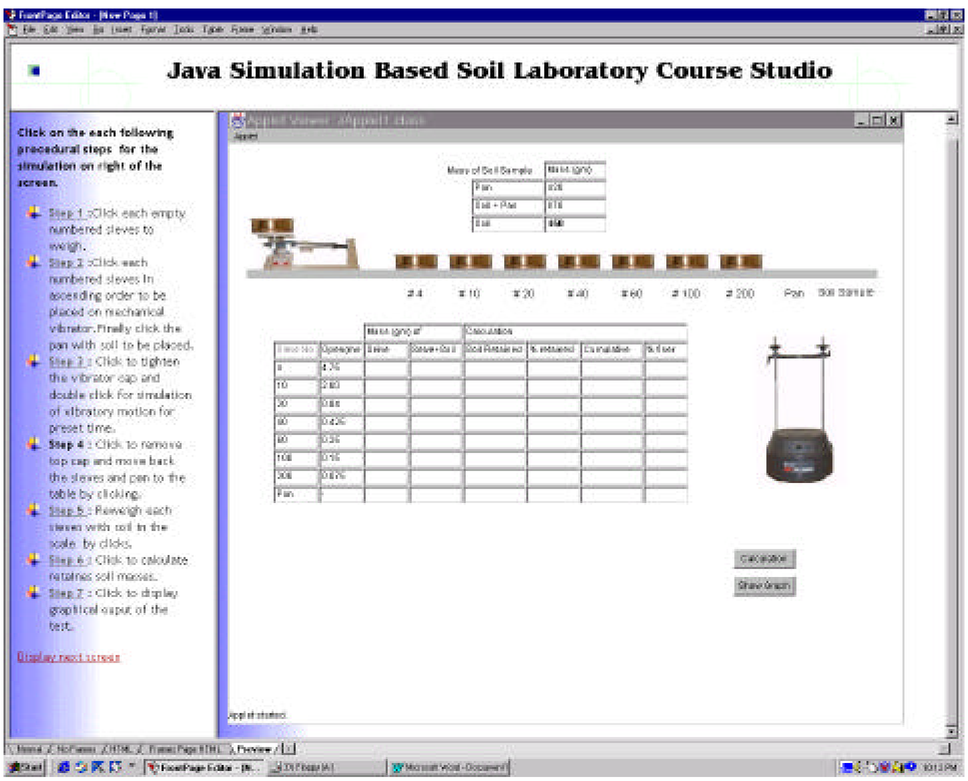

Figure 2. A sample model screen for the development of Java simulation model

After placing the stack of sieves on the shake table, shaking is simulated using a timer as shown in Figure 3. The weight of the soil sediment retained on each sieve is measured and entered into the table by user participation. Both graphical and tabulated methods of data presentations are developed for the interpretation of simulated data. Figure 4 shows a sample screen of the tabulated computations and graphical representation of the soil particle size distribution.

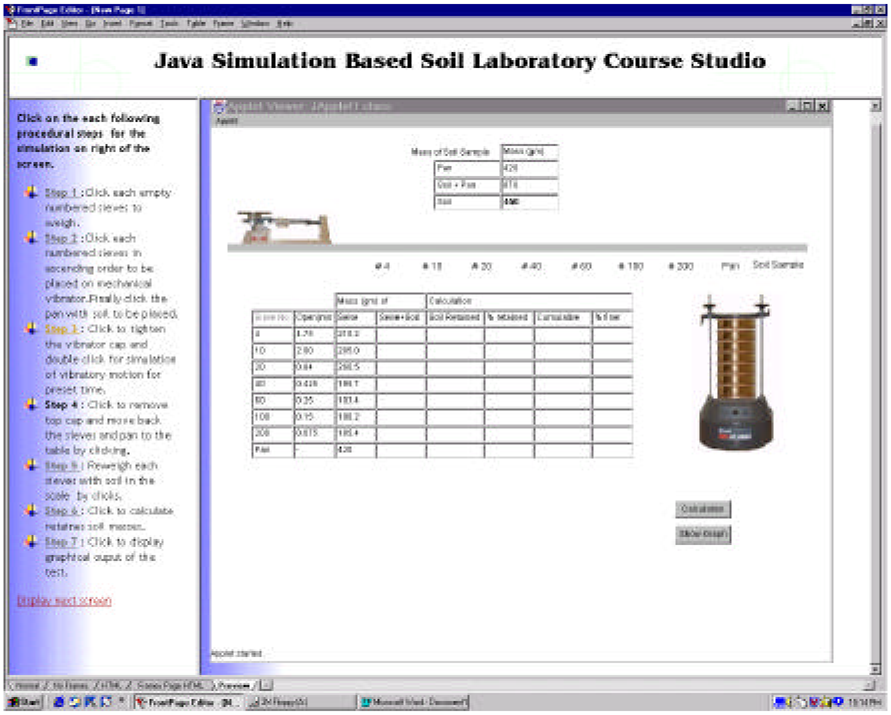

Figure 3. A sample screen showing simulation of the stack of sieves shaking.

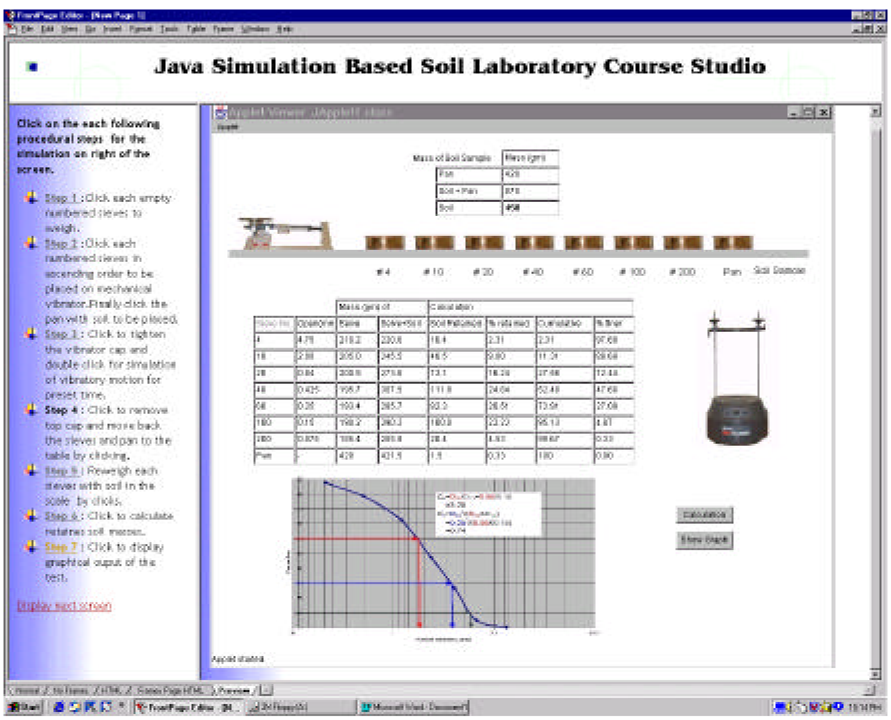

Figure 4. A sample screen showing tabulated computations and graphical representation of the simulation test results

III. Development Platform:

The principal software used to develop the presented laboratory studio was Symantec's Visual Café 3.0. It is a complete form-based development environment that provides a rich set of What-You-See-Is-What- You-Get (WYSIWYG) tools and components that are very user friendly to develop, debug, and deploy high-performance Web applets and stand-alone Java applications. In addition to that some other software were used, such as Macromedia Dreamweaver 2.0, and MS FrontPage2000.

IV. Preliminary Evaluation and Implementation Plan

A qualitative survey produced many responses from both graduate and undergraduate students and helped improve the contents and the user interface of the proposed soil mechanics virtual studio. This software will be installed on computers in the construction engineering computer laboratory and later on departmental website. The students will be able to access the software during scheduled lab time. It will be introduced to undergraduate students for their soil mechanics laboratory class for the fall 2000. A complete summative evaluation of this software will also begin during fall 2000.

V. Concluding Remarks

Based on the results of this study, it is concluded that effective integration of computer simulation into traditional lecture-lab activities such as soil mechanics as presented in this paper enhances the performance of the students. Guided computer simulation activities can be used as an educational alternative to motivate students into self-discovery and to develop their reasoning skills. The lab activity can then focus on the actual transfer of knowledge. This strategy helps improve the effectiveness and efficiency of the teaching-learning process. In situations where the objective of instruction is to learn the facts without application or transfer, method of instruction is not a significant factor. However, if the educational goal is for students to transfer and apply the knowledge to real-world problems, then simulation integration into the class structure is an effective learning strategy.

Although multimedia is generally considered as an individual pursuit, authors' study suggests that its use in classes with a large audience can be accommodated, provided that it is linked directly to the achievement of a specific group of learning objectives. In this sense the proposed design studio model is seen to act as a navigator rather than as an oracle or source of knowledge. One of the true benefits of the proposed courseware model is its flexibility of usage. The informal feedback from students has been positive in that they see it as being a useful self-learning mechanism. Although the presented approach is being applied to soil testing laboratory, it employs a generic architecture, which is discipline independent and can be adapted to any other similar domain which will certainly promote and enhance students’ understanding.

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