

Engineering Education Using Resources In Digital Libraries

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Abstract - Digital libraries have been and are being created in a number of countries. In the USA, the National Science Foundation has created a National Science, Mathematics, Engineering and Technology Digital Library (NSDL). One of the digital libraries within NSDL is the Geotechnical, Rock and Water Resources (GROW), which is Phase 1 of a National Civil Engineering Educational Resources Library. GROW and NSDL have links to high quality learning materials that can be used to develop courses for different audiences ranging from middle school to graduates and professionals. Moreover, these digital libraries provide a new environment for individual and collaborative learning. This paper deals with the use of educational materials within digital libraries to create engineering courses and training materials, and delivering them via the web.

Index Terms - Digital libraries, Engineering Education, Virtual Laboratory, Simulation.

BACKGROUND

The Web has become the primary system for publication and dissemination of information anytime-anyplace. The growth of information on the Web has been phenomenal. This growth has, however, come at a price. It has become time consuming and often frustrating to find quality information on topics of interest. A search using search engines such as Google will normally find dozens, perhaps hundreds of hits. The user now has to sift through the hits and this could be very time consuming and frustrating. One way to alleviate the frustration and to find quality resources is to develop digital libraries with quality collections that let users discover and interact with digital resources anytime-anyplace.

Several digital libraries are now in existence. One digital library under development is the National Science, Mathematics, Engineering and Technology Education Digital Library (NSDL) sponsored by the US National Science Foundation. NSDL [1] is envisaged as a network of resources to enhance the quality of science, mathematics, engineering and technology education. One of the subsidiary NSDL libraries is the Geotechnical, Rock and Water Resources Digital Library (GROW).

Geotechnical engineering involves the use of fundamental laws of physics to understand the mechanical behavior of soils for the design of earth systems such as foundations, dams, tunnels and slopes. Rock engineering is similar to

geotechnical engineering except the material is rock rather than soils. Water resources engineering involves works relating to, for example, the design of reservoirs, rivers, dams, drainage and irrigation schemes.

A team of educators, resource creators, librarians, computer and assessment specialists from different units (College of Engineering & Mines, University Library, School of Information Resources and Library Science, Computer and Communication Information Technologies, and Assessment and Enrollment Research) within the University of Arizona was assembled to develop, collect, transform and disseminate digital information on geotechnical engineering, rock engineering and water resources engineering. The architecture developed for GROW [2] is illustrated in Fig. 1.

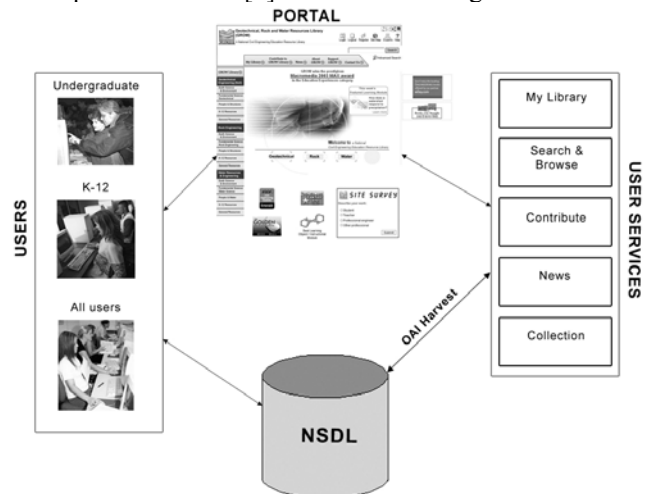


Figure 1 GROW's architecture

The collections in GROW are focused on interactive, multimedia, educational resources that are "story-booked" to emphasize active learning and provide a learning experience rather than providing snippets of information. It consists of a hierarchy of learning objects to meet the needs of users from K-12 to continuing education for professionals. The underlying hypothesis is that base resources can be repackaged to provide quality information at the appropriate learning level.

Engineering projects require engineers to conceptualize, visualize and realize. All this is done through engineering drawings mentally and physically. Most engineering activities are also hands-on and include a sequence of interactive events for success. Consider the design and construction of a bridge. A civil engineer will create a mental picture and will then

draw sketches of the bridge before proceeding to calculations. When calculations are completed, the results are then transferred to drawings that are used for construction. The public sees the bridge after construction and then form opinions based on its look and, in some cases, its functionality. Our goal is to capture the functional environment of engineers and the way the public perceived engineering works to enhance learning. By using graphics and interactivity, we also capitalize on the rich graphics environment provided by computer technologies.

NEW LEARNING ENVIRONMENT USING DIGITAL LIBRARIES

NSDL and GROW are digital library collections of quality information and resources that are accessible to anyone with an Internet connection to be used in ways that best suit the user. The question that will be addressed in this paper is “How can these digital collections be used to create learning environments to meet the needs of educators and learners? One way is to create a digital library with a collection of quality resources and tools that is organized and customized to different audience groups such as K-12 students and teachers, higher education, practitioners (working engineers and technicians) and the general public (Fig. 1). For example, as members of a community, we get much of our information from the news media. We often read in the newspaper about the damage caused by floods, earthquakes and other natural occurrences. Sometimes, the reports on the technical issues from these natural occurrences are flawed and the public is not well served (well-educated on the issue) because the reporter or reporters may not have had access to quality technical information in a timely manner. A digital library of resources on floods, etc., available anytime and at any place would not only provide news media reporters (science writers and others) with appropriate quality technical information but will also provide ready access for members of the community to verify the information at the appropriate learning level and learn more if so desired.

To prepare courses, training materials or course packets for distance or in-house education at any level require developers (instructors) to invest substantial amount of time and have a good working, technical knowledge of the web. Digital libraries can substantially reduce time and technical knowledge requirements to prepare courses and other educational materials.

After graduation, an engineering graduate normally works for a number of years and then may take the required examinations to be licensed and to be registered as an engineer in a particular field of practice. In many states, there are requirements of certain number of credit hours of courses for re-licensing. The question that most of these engineers face is how best to continue to work full time and get the required education for continuing licensure and registration? One of the goals of GROW is to provide some of the building blocks or learning objects that will facilitate engineers to obtain quality, continuing education learning materials anytime-anyplace.

Digital libraries such as GROW allow users to have access to high, quality educational materials prepared by world-class teachers. These materials can be used to teach students or students can assemble their own collection for self learning (Fig. 2). Tools are available for cooperative interactions with students, teachers and experts from distant locales.

A New Way to Teach and Learn

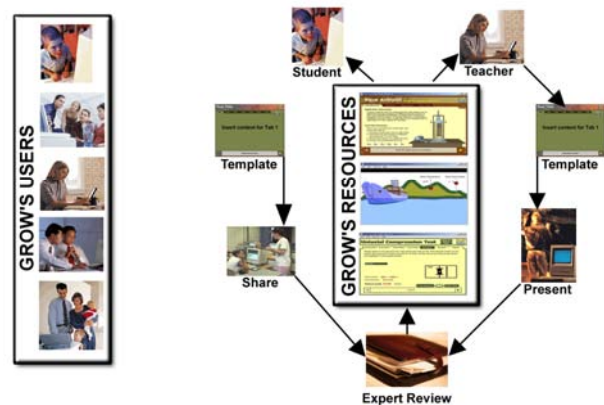


Figure 2 Utilization of GROW's resources

PUBLIC CONTRIBUTION AND REVIEW OF RESOURCES

GROW provides the public with opportunities to contribute resources. All resources are reviewed based on the following criteria before they are posted to the site for public access.

- Relevance.
- Technical accuracy.
- Pedagogical effectiveness.
- Usability.
- Documentation.
- Potential to enhance learning.
- Robustness/sustainability.

In the GROW project, a voluntary peer and user review process was developed that allows content to be reviewed by a panel of expert reviewers and also by the user community. The review process ensures that only quality, accurate materials are available through GROW.

EXAMPLES OF ACTIVE RESOURCES IN GROW

GROW has over 100 interactive resources in engineering. Three examples are briefly described below.

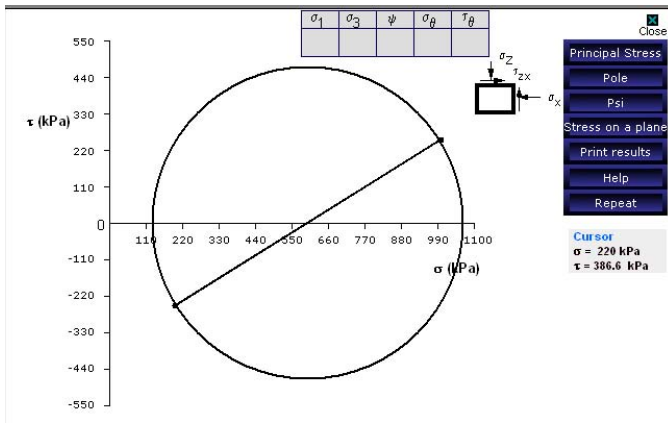


Figure 3 Interactive Mohr circle.

Example 1 is an interactive Mohr circle module (Fig. 3). From this module, the students are guided on how to use Mohr circle to find stress states and to interpret the results. The student specifies the stresses and the Mohr circle is drawn. To find the principal stresses, for example, the principal stress button is clicked and the student is guided to determine the principal major and minor stresses from the graph. The student can repeat this as many times as desired or can draw multiple Mohr circles to visualize the effects of different imposed stresses.

Manning's Equation

Irrigation Canal Surface Roughness

The rate of flow of water in channels is a function of the slope of the channel, the roughness of the channel surface material, and the shape of the channel. This relationship is called Manning's equation. It is true for streams and also constructed canals and ditches. The following experiment allows you to see how the channel rate of flow varies with the roughness of various surface materials. Irrigation canals and ditches are often cleaned of weeds and debris before the irrigation season in order to better transport water to farmers during the growing season.

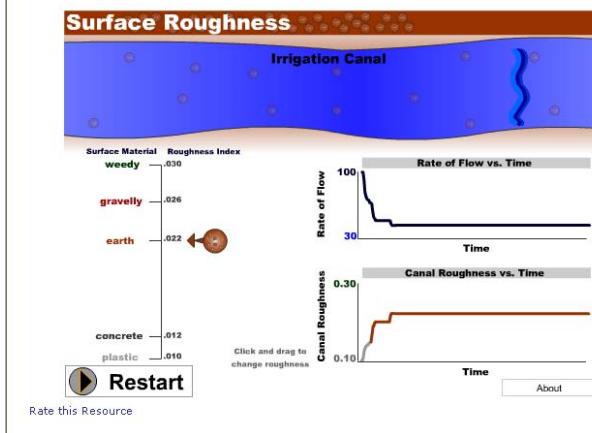


Figure 4 Interactivity for Manning's equation.

Example 2 is an interactive exercise on how the flow predicted by Manning's equation is affected by channel roughness (Fig. 4). Here the student changes roughness based on typical channel materials and view how the flow changes with time.

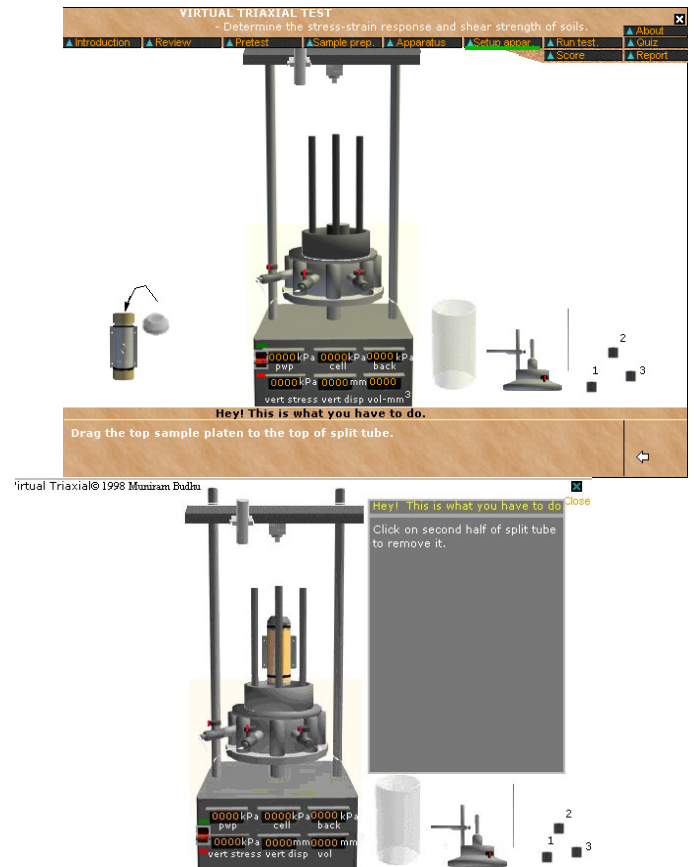


Figure 5 Two steps in conducting a virtual triaxial test.

Example 3 is a group of resources on virtual laboratories. The benefits of a virtual laboratory are:

- Enhancing retention and transfer of learning.
- Supplementing and acting as a precursor for actual laboratory tests.
- Better preparation of the students for the real tests.
- Testing skills and knowledge that are not currently tested.
- Enhancing learning about laboratory procedures, interpreting of test results and applying the results to practical situations.
- Integrating basic theoretical concepts/principles with laboratory exercise.
- Extending the range of soil testing.
- Alleviating shortages of equipment, lack of equipment and inadequate space
- Enhancing the connection among theory, experiment and application.
- Providing self-paced instructions.
- Meeting the needs of students in remote areas where experimental facilities may be absent or there is a lack thereof.
- Providing instructors with a tool to demonstrate in class the procedures of laboratory tests and interpretation of the results.

- Providing feedback to the instructor on concepts that are not well understood so that remedial actions can be taken.
- Easy accessibility for some students with physical disability.

The instructional interactions developed in the virtual laboratory courseware are intended to:

- stimulate recall of prior knowledge,
- let each student conduct virtual tests in his or her apparatus independent of location and time,
- allow the students to observe relationships from various graphs and determine the relevant soil parameters,
- test key principles on the subject matter and provide immediate feedback.

One of the virtual laboratories is a triaxial test on soil samples. The educational goals in the virtual triaxial test are to test a student prior knowledge that is relevant to the laboratory procedures, to test learning outcomes from the laboratory exercises, to let the student apply his/her tests results to a practical scenario, to provide immediate feedback, performance evaluation and help. Before the student begins the virtual laboratory test, he/she is instructed on (1) the purposes of the test and why it is important (2) what he/she has to do, and (3) the grading scheme. The student then answers a quiz to test pre-requisite knowledge. The answers are scored and this score is available to the student. The student is allowed three attempts to get the correct answer with decreasing scores for each attempt. After three wrong answers, the solution is displayed. A record is kept of all incorrect answers and this record is available to the student and can be e-mailed to an instructor for feedback. The instructor can use the records from all students to make any necessary adjustments to the course. After testing the pre-requisite knowledge, the student proceeds in the following order.

1. Becomes familiar with the parts of the apparatus.
2. Prepares a test sample by jacking it out from a tube.
3. Prepares the sample and the apparatus for a test. The student drags the disassembled parts of the apparatus and assembles them for the test as illustrated by two of the steps in Fig. 5.

Once all the set procedures have been satisfactorily completed, the student proceeds to apply loads to the sample and observe the results (Fig. 6). The student is then prompted to interpret the results and then apply them in a practical situation.

Each student has his/her apparatus and soil samples are generated randomly. The data that the student gets from the virtual test are simulated based on constitutive relationships and test data from real soils. Perturbation functions are randomly introduced to alter the data so as to mimic the vagaries of real soil responses. For example, some stress points in a stress-strain plot are shifted from those predicted using the constitutive relationship to make the stress-strain curve slightly irregular to match the responses of real soils.

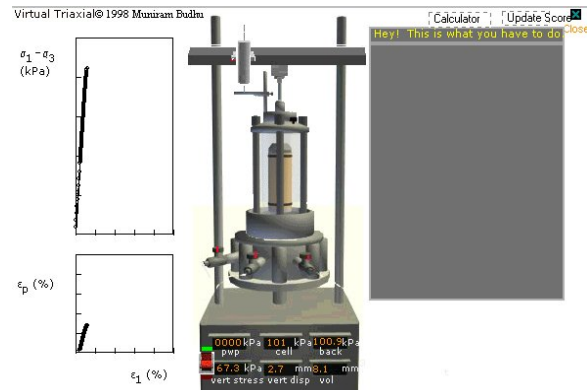


Figure 6 Part of the results of a virtual triaxial test.



Figure 7 A web course prepared using GROWTutor.

GROWTutor

Digital libraries contain a vast amount of quality, educational materials. How can the resources in these digital libraries be sequenced into dynamic courses that can be changed to meet different learning needs? The GROW team developed GROWTutor from the open source software, Atutor [3], as a resource sequencing template to assemble and present courses and training materials using educational materials in digital libraries or elsewhere. GROWTutor also has a learning management system (LMS) that incorporates registration, pre-assessment tools, instructional content, activities and learner interactions, post-assessment and metric tools. GROWTutor is SCORM compliant. Therefore, any object created in GROWTutor could be exported and used on its own or with any SCORM-compliant LMS. An example of a course developed using digital library resources is illustrated in Fig. 7. This course is delivered via the web and managed by GROWTutor.

CONCLUSIONS

Digital libraries provide a variety of high quality resources to assemble into courses and training materials anytime-anyplace. A tool, the GROWTutor, is available to allow instructors to develop and manage web-based courses without the need for significant technical knowledge of the web.

ACKNOWLEDGMENT

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REFERENCES

- [1] <http://www.nsd.org>
- [2] <http://www.grow.arizona.edu>
- [3] <http://www.atutor.ca/>