A DIGITAL LIBRARY FOR CIVIL ENGINEERING WITH AN EMPHASIS ON LEARNING UNITS

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Abstract *¾ A digital library for Civil Engineering is being developed at the University of Arizona. The initial focus of the digital library is on collections in three targeted areas: geotechnical engineering, rock engineering, and water and its use (Geotech, ROck, and Water, GROW). There are several unique aspects to the GROW digital library. First of all, the library will address specific learning and content needs for a number of different audience groups, including K-12, higher education, professionals and the community at large. Secondly, the collections will utilize modern multimedia techniques to promote active online learning. Thirdly, the GROW digital library collections will focus on "learning units" which are self-contained learning lessons that provide clear educational objectives and outcomes. As part of the digital library, a host portal is being developed that will provide easy access to the collections in the three target areas.*

Index Terms ¾ Digital library, civil engineering, active learning, multimedia, rock, geotechnical, water

INTRODUCTION

The web has become an important tool in engineering education, particularly for online learning environments such as online courses. There are a number of current approaches being used for online course delivery. The most common approach focuses on text and graphics, much like a traditional textbook. This approach still has many educational advantages over a textbook, including the ability to use links, the ease of updating material, and instant access to the material around the world. The primary disadvantage of this approach is that it caters to a learning style much different than the traditional lecture: reading text as opposed to watching and listening. More innovative approaches include the use of streaming audio, streaming video, and animation. These approaches cater to the same learning styles of students in a traditional classroom, and can be used in conjunction with a discussion forum to promote interaction. The primary disadvantage to these approaches is the large bandwidth requirements associated with streaming video and animation. This disadvantage can be reduced by the use of streaming audio to replace streaming video and the use of vector graphics and animation (via programs such as Macromedia Flash) to replace bitmap graphics and animation [1,2].

Digital libraries have many similarities with online courses. A digital library is an online source of information about a topic or range of topics. Digital libraries contain a wide variety of media types, ranging from arrays of educational building blocks (text files, images, sound files, video clips, etc.) to complete learning modules that educate the user in a particular subject. Metadata searching is an important element of digital libraries, and useful search engines allow searches for media type, learning outcomes, audience level, rating, etc. Many if not most digital libraries depend on contributors for the building and sustainability of the information. This allows a large, ongoing source of information to be compiled, but there are difficulties controlling the type and format of the information. Like online courses, there are a variety of approaches to presenting material in digital libraries. These libraries are thus susceptible to the same deficiencies as online courses with regard to catering to different learning styles. Also, unlike an online course that is designed for a specific educational level, digital libraries are generally open to users of all ages and educational backgrounds. This presents challenges for digital library developers.

A digital library for Civil Engineering is being developed at the University of Arizona [3]. The initial focus of the digital library is on collections in three targeted areas: geotechnical engineering, rock engineering, and water and its use. The Geotechincal, ROck and Water Engineering (GROW) Digital Library at the University of Arizona is an NSF-Funded NSDL project built on collaboration between campus units. A team has been assembled that brings together faculty and staff from the College of Engineering, the University Library, the School of Information Resources and Library Science, the campus computer center, and the campus teaching center. There are several unique aspects to this digital library. First of all, the library will address specific learning and content needs for a number of different audience groups, including K-12, higher education, professionals and the community at large. This means that a given topic area may be "repackaged" separately for these different groups. Secondly, the collections will utilize modern multimedia techniques to promote active online learning. This includes interactive learning modules rich in

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animation, video, sound and images as well as an interactive questioning environment. As part of the digital library, a host portal is being developed that will provide easy access to the collections in the three target areas and to allow for the growth of the collection in other areas of civil engineering. An advisory panel is assisting us in various aspects of the library.

This paper describes the GROW digital library. First of all, the paper describes one of the unique aspects of the GROW digital library, which is its emphasis on "learning units". Secondly, the paper will briefly describe the individual geotechnical engineering, rock engineering and water collections. Thirdly, the paper will describe how the infrastructure for the GROW digital library is being developed.

LEARNING UNITS IN THE GROW LIBRARY

The web is capable of presenting a wide variety of media, including text, images, sound, animation, and video. However, presenting interactive multimedia on the web does not guarantee a learning environment for the viewers of the media. An interactive web activity can be compared with a classroom activity. The classroom activity in isolation would probably be confusing and have little educational value for the student. What gives the activity educational value is the context in which it is placed, and having well defined learning objectives and outcomes. A good classroom activity, for example, will start with an introduction to provide the context. Leading questions may be asked at this time to get students interested in the problem. The activity will be followed by exercises to reinforce what students have learned, and a summary to inform students of the desired educational outcomes. Further challenges (questions, quizzes, reports, etc.) may also be given, and students will then be directed to additional sources of information for outside learning. This allows more advanced students to gain additional knowledge related to the subject manner. Overall, the pre-activity, activity and post-activity exercises constitute what we call a "learning unit".

We are also utilizing the concept of a "learning unit" in the GROW digital library. We define the learning unit as the smallest self-contained lesson in the GROW digital library. A learning unit contains "elements", which consist of text, images, video, flash animation, etc. An example of a learning unit from the Rock Engineering part of the GROW library is shown in Figure 1. It is a tutorial on the point load laboratory test and consists of seven parts: introduction, test procedure, sample preparation video, sample test video, rock break simulator, analysis, and report. The user would normally proceed through the learning unit in the order listed above. The point load learning unit shown in Figure 1 has a clear learning objective: to teach the user how to conduct and analyse data from the point load test. The learning unit also assesses the success of meeting the learning objective: a report that the user completes online.

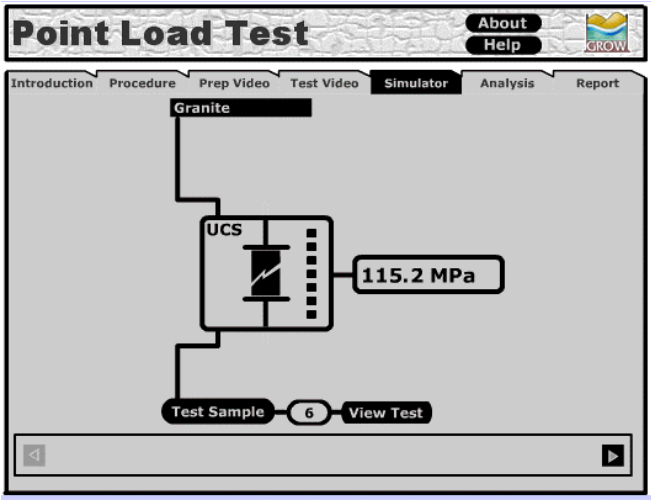

FIGURE. 1
EXAMPLE OF A LEARNING UNIT FOR A ROCK VIRTUAL LAB AT THE UNDERGRADUATE COLLEGE LEVEL. IT CONSISTS OF A NUMBER OF PARTS, INCLUDING AN INTRODUCTION, VIDEO CLIPS OF SAMPLE PREPARATION AND TESTING, A ROCK SIMULATOR TO GIVE UNIQUE RESULTS TO THE USER, AND A REPORT FOR THE STUDENT TO FILL OUT.

We plan to emphasize the use of learning units in the GROW digital library. The learning units can be utilized stand-alone or, as a more likely scenario, as part of a collection of learning units completed in a particular sequence, called a "module".

THE GROW COLLECTIONS

This section of the paper gives specific details on the collections in the GROW digital library in the three initial target areas: Geotechnical Engineering, Rock Engineering, and Water and Its Use.

The Rock Engineering Collection

Dr. Kemeny is in charge of the targeted collection on rock engineering. The field of rock engineering is broken up into 6 topics: prerequisite science, rock engineering fundamentals, virtual lab, rock engineering modeling and design, virtual field trip, and research. This is shown in Table I.

TABLE I
TOPICS IN THE ROCK ENGINEERING COLLECTION

Topics	Subtopics
Prerequisite science	Math, Statics, Geology, Strength of mater, Statistics, Computer science
Rock engineering fundamentals	Intact rock, Discontinuities, Rock mass, In-situ stress, Induced stresses
Virtual lab	Uniaxial, Triaxial, Point load, Brazilian, Direct shear, P and S wave

Design and modeling	Slopes, Foundations, Underground, Computer models
Virtual field trip	Rock mass characterization, Monitoring
Research	Coupled processes, Imaging techniques, Modeling, Excavation, Slops, Fractures, Nuclear waste, etc.

The major subtopics within each topic are also shown. For each of these topics the digital library will contain collections that cater to the 5 audience groups: community, K-12, undergraduate, graduate, and professional. As an example, consider laboratory testing. For the learning units within this topic the undergraduate, graduate, and professional "versions" are virtually identical and will be similar to that shown in Figure 1. However, for the K-12 and community versions, repackaging of the material will take place. For these two audiences, the focus will be on why testing is needed, the rock breaking simulator to allow students to test their own rocks, and information about where the results would be used in engineering design.

Dr. Kemeny is drawing on a number of sources in building the rock engineering collection. First of all, Dr. Kemeny is utilizing some of his own work [1,4]. Secondly, Dr. Kemeny is drawing on active individuals and organizations in the rock engineering community. One of the most important organizations is ARMA, the American Rock Mechanics Association [5]. This organization reaches out to the various industries, academic disciplines, government agencies, and international organizations involved in rock engineering, and also hosts an annual rock mechanics symposium. The rock engineering digital library will be open to all individuals to contribute information. In the spirit of the proposed work, these individuals should be interested in working with us to repackage the material to all of the 5 targeted audience groups, and to utilize the concept of the learning unit in work that is contributed.

The Geotechnical Engineering Collection

Dr. Budhu, the project director, is responsible for the targeted collection on Geotechnical Engineering. The major topics for geotechnical engineering are: fundamentals of geotechnical engineering, virtual geotechnical lab, virtual site investigation, foundation design, numerical modeling, and virtual construction of foundation. Each of these have subtopics. For example, the subtopics for the virtual geotechnical lab are shown in Table II. As an example, the interactive sieve analysis virtual lab is shown in Figure 2.

Dr. Budhu is drawing on a number of sources in building the geotechnical engineering collection. First of all, Dr. Budhu is utilizing some of his own work [7]. Secondly, Dr. Budhu is drawing on active individuals and organizations in the geotechnical engineering community.

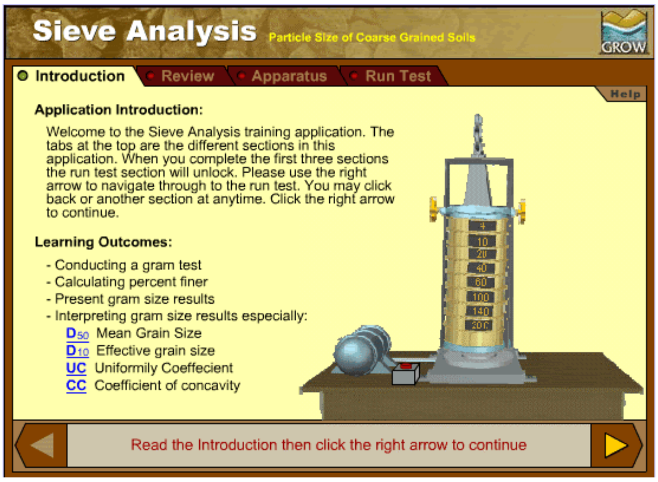

FIGURE 2
AN EXAMPLE OF A VIRTUAL LAB AS PART OF THE GEOTECHNICAL COLLECTION.

TABLE II
TOPICS IN THE VIRTUAL LAB PART OF THE GEOTECHNICAL COLLECTION

Topic	Subtopic
Virtual Geotechnical Laboratory	- Water Content - Grain size - Index tests - Consolidation - Direct shear - Triaxial - Simple shear - True triaxial - Hollow cylinder - Residual shear

The Water and Its Use Collection

Dr. Rasmussen is in charge of the targeted collection on water and its use. The water collection will house information on and offer links to water-related material that is suited for each of the target audience types to understand and use. A list of topics that are now being developed include water science, hydrologic cycle, people and water, water quality, waste water, and infiltration. Each of these have subtopics. For example, the subtopics for the water science topic are shown in Table III. An example of the bouyancy tutorial is shown in Figure 3.

TABLE III
TOPICS IN THE WATER SCIENCE PART OF THE WATER AND ITS USE COLLECTION

Topic	Subtopic
Water Science	- Volume - Weight - Density - Surface tension - Water composition - Water quality - Pressure - Temperature - Index of refraction - Buoyancy - Viscosity - Capillarity - Rate of flow - Physical state - Flowing water - Diffusion

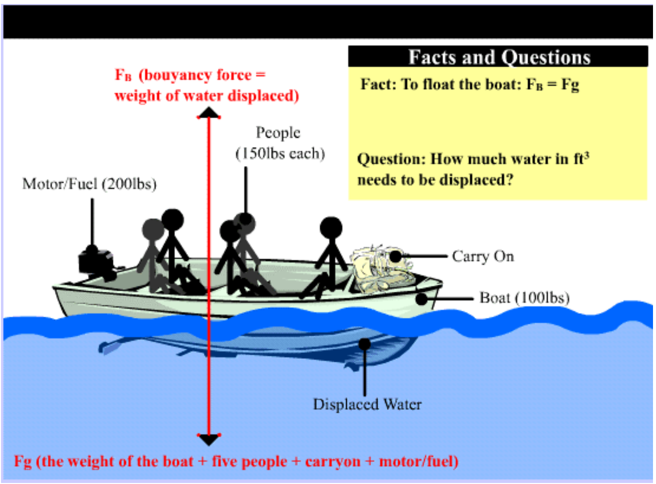

FIGURE 3
A TUTORIAL ON BUOYANCY FROM THE WATER AND ITS USE COLLECTION.

THE GROW INFRASTRUCTURE

This section provides information about the GROW digital library infrastructure. The system architecture in the GROW digital library provides for the ability to store, maintain, access, identify, and use the content of the three collections. It contains 3 layers: a storage layer, a logic layer, and a portal layer. The first layer, storage, provides the actual content (learning modules, articles, media, etc.). On top of the storage layer sits the logic layer. This logic section provides the necessary information and metadata to discover, identify, and access the content in the system. On top of the logic layer rests the portal. The portal provides customized access to content, and allows the user to search and find relevant content and tools.

Consistent among all of the system layers is the use of open standards. Using open standards, such as XML, XSL, Dublin Core, OAI, etc. provides better and easier interoperability with a variety of content, and with other educational systems. Additionally, as appropriate, the software will be open source – that is, we will make the code freely available for others to implement, use, customize, and improve. By using a combination of open standards and open source software, we allow participation from both content and system adopters and provide a greater ability for others to implement and understand.

The storage layer provides room for the content of the proposed project. The storage layer will be split into two areas, the database and the file server. The database, which will run on a MYSQL instance, will contain the metadata about the content. Along with the content metadata the database will store dropdown data that will be used on the web page, user information and content reviews. The database schema allows for multiple entries of certain metadata fields and also allows content to be linked. The metadata in the database will be retrieved using SQL and OAI protocols. The actual web page text, flash movies, audio, movies, images will be stored on a file server.

The logic layer, or glue, that will take requests from the web page and execute them or take a response from the storage layer and format it before returning a response to the webpage. This layer will contain all the processing logic of the site, it will perform searches and return results, take metadata content and write it to the database, perform a login/logout of a user or respond to a NSDL harvest of the GROW metadata. The logic layer will be coded in Java and will possible use XML and XSLT. We plan to use Apache as a web sever with Tomcat running on it. Tomcat is a servlet container and will be used to house our java servlets and JSPs.

The metadata schema will be a combination of Extended Dublin Core records and records that will be specific for the GROW website. Each learning module or singular piece of content will be provided a metadata record. This metadata record will contain descriptive information that will allow a user to search for and determine if a piece of content is relevant to their needs. It will also contain information that relates it to other content within the system, as well as information on rights and copyright, and other administrative information.

The portal will be the public face of the project, and will provide access and organization to content for users [3]. It will be web-based and information will be organized by topic to insure the easy discovery of appropriate resources. Users will be able to evaluate resources through the portal by providing user feedback and comments on individual pieces or modules of content. The portal provides the ability to customize the delivery of content to users, by allowing the option for user accounts and logons.

CONCLUSIONS

The GROW digital library for Civil Engineering is being developed at the University of Arizona [3]. The initial focus of the digital library is on collections in three targeted areas: geotechnical engineering, rock engineering, and water and its use. An interdisciplinary team has been assembled that brings together faculty and staff from the College of Engineering, the University Library, the School of Information Resources and Library Science, the campus computer center, and the campus teaching center. There are several unique aspects to this digital library. First of all, the library will address specific learning and content needs for a number of different audience groups, including K-12, higher education, professionals and the community at large. Secondly, the collections will utilize modern multimedia techniques to promote active online learning. This includes interactive learning modules rich in animation, video, sound and images as well as an interactive questioning environment. Thirdly, the GROW digital library collections will focus on "learning units" that are self-contained learning lessons and provide clear educational objectives and outcomes. As part of the digital library, a host portal is being developed that will provide easy access to the collections in the three target areas and to allow for the growth of the collection in other areas of civil engineering. As part of the architecture for the library, a number of different types of reviews of submitted material will be possible, including academic reviews for quality control and user reviews. The educational value of the submitted material and of the library as a whole will also be assessed through an advisory panel consisting of teachers, students, professionals and other members.

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