A FRAMEWORK FOR TEACHING COMPUTATION TO STEM STUDENTS IN E-LEARNING ENVIRONMENT (TECSSEE)

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ABSTRACT— To address the lack of computer assisted learning environments designed specifically for education in STEM (science, technology, engineering and mathematics), we propose a web-based e-learning environment via visualization, integrated with social learning, to meet the need from different disciplines in STEM (TECSSEE). The web service comprises of a three tier organization, including demos, hands-on labs, and quizzes. In the demo, students are shown how to use a certain application; during hands-on labs, students are asked to solve real-world problems in an active learning style, which means the students need to manipulate all the input data, parameters and rules, and see how data is visualized according to different factors, to learn about the concepts; last but not least, quizzes are given to the students as examinations of the learning. In addition, social learning will be incorporated in this system, students are provided with a social networking site offering group discussion, group blogs and wikis as further assistance to each specific hands-on lab.

Keywords: Visualization, e-learning, blended learning, hands-on labs, U learning, active learning, social learning.

1. INTRODUCTION

STEM education refers to the fields collectively considered core technological underpinnings of undergraduate teaching and learning. Many STEM classes incorporate computer assisted teaching methods to some extent. Virtual teaching platforms, such as Blackboard, have been used in a variety of teaching institutions. Blackboard develops and licenses software applications and related services to over 2200 education institutions in more than 60 countries (Blackboard Inc.). In Spain, 71.8% of university teaching and research staff make use of institutional virtual teaching platforms and 92.5% of the students make use of such platforms (CRUE, 2009).

The current trend to complement traditional face-to-face classes with electronically supported teaching and learning is known as “e-learning”; this style of learning is usually used to reference out-of-classroom and in-class-room education via technology. Under situations where student numbers are high, the use of e-learning can produce better outcomes in learning practices and patterns; they are widely applied in large-scale classes, such as first year of undergraduate study, which is an important year to help students build up commitments to university learning (Huon, 2007).

E-learning has gone through two phases, from simply reconstructing textbook contents which are taught in the classroom to building up various delivery models for the students. Numerous approaches have been designed to meet the need, the teaching media include, but not limited to, technologies such as Internet, intranet/extranet, audio or video tape, satellite TV, and CD-ROM.

Currently, widely used e-learning systems comprise of mainly general purpose applications, such as Blackboard, GOAL and Moodle. They are good extensions of traditional classroom activities, such as lecture, homework, and tests. An e-learning platform like this is not fully utilizing the power of computer and network, only limited capability has been offered. In this paper we will introduce a framework of e-learning where students can visualize course content and interact with the platform in an active learning pattern so that better teaching and learning efficiency is achieved.

2. RELATED WORK

Hazem M. El-Bakry, et al, have proposed Service Oriented Architecture (SOA) as a design pattern that presents systems as collection of reusable services that can be exposed and consumed on the Internet with standard interfaces (Hazem M. El-Bakry, 2009). Maja ukušić, et al, designed and assessed a comprehensive model for managing the e-learning process and to define the relationship between systematic implementation of the model, outcomes of certain e-learning aspects and subject of e-learning (Maja ukušić, 2010). Chao Boon Teo and his colleague have pointed out that current LMS are still limited to just being online repositories, lacking of learning personalization, and they have proposed a methodology for eliciting and personalizing tacit knowledge (Chao Boon Teo, 2006).

Chaofan Wang, et al, introduce visualization techniques to the teaching and learning process of the highway engineering experiment (Chaofan Wang, 2010). An E-portfolio is introduced to the Distance Chinese Language Visualization Teaching Platform, then designs the function modules of E-portfolio according to the function requirements analysis is described, and the application of E-portfolio in Chinese learning and the evaluation process based on it is explained (Yi Zhang, 2008).

3. THE E-LEARNING WEBSITE

This e-learning environment is focused on providing visualization experiences for STEM education, including biology, chemistry, computer science, mathematics, and etc., as shown in figure 1. All the disciplines are independent. Each contains one or more hands-on labs providing insights to a certain project where students are required to work by themselves. On this site, an interactive visualization style is used throughout all visualizing labs, which means the system will interact with students' input. As one input a set of data, the system will present visualized figures. If input data is changed or modified, the output will be adjusted accordingly.

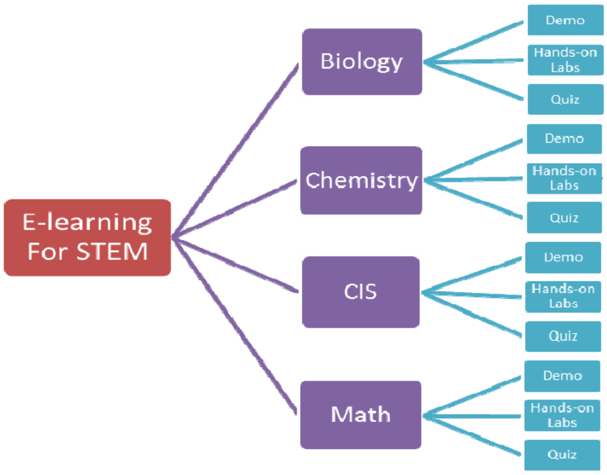

Fig. 1 3-tier of TECSSEE

The website will not be open to public, for the reason that we are currently focusing on providing STEM disciplines within Florida A&M University only. As seen in figure 2, each student will have a profile stored on the website, at the time of login, authentication is required. Student profiles are to be created by administrators.

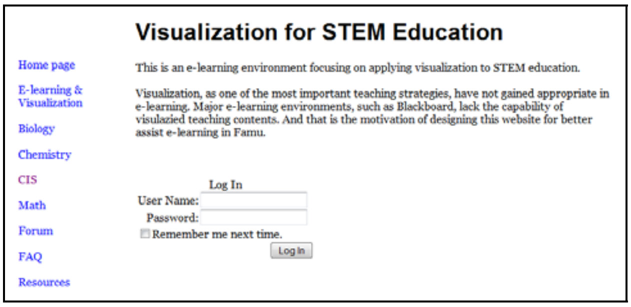

Fig. 2 Homepage with logon

The navigation menu on the left provides accessibility to all the resources on this website, including entries to lab projects of STEM disciplines, and other useful information. The main part of this site will be constructed in Microsoft .Net Framework; however, other script languages may be incorporated as well when necessary.

4. DESIGN OF TECSSEE

The goal in this paper is to create a visualizing environment for STEM education, different from other approaches, including extension of traditional classroom interactions such as Blackboard, advanced teaching and research software packages such as Matlab which is complicated and costly to general students, and simple applications with very limited functionality, such as the Visualization Tools for Teaching Computer Security website (Visualization Tools for Teaching Computer Security), which provides static demonstrations of information security issues without offering real hands-on labs to the students. Our site will be employing visualization in an active learning style with real hands-on labs so students have "learning by doing" experience.

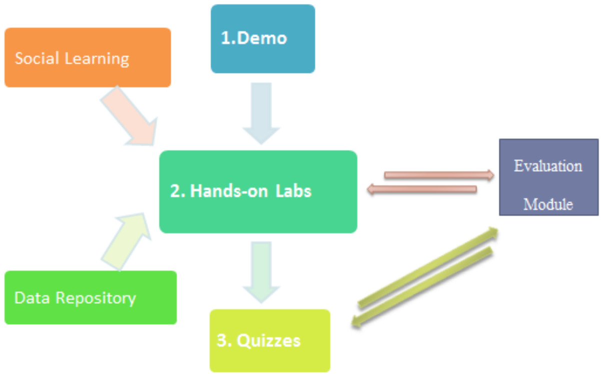

Fig. 3 Structure of TECSSEE

Such experience will be offered in a three tier style assisted by social learning and a data repository, as shown in figure 3.

4.1 DEMONSTRATION

One of the most significant problems with current e-learning applications is that the learning curve is sharp. When getting to a new environment, students will often experience frustration when there are no simple and easy guidelines to follow. To address this issue, we will use Jing screencasting computer program and open source video recording software CamStudio to record how each application works, and offer students the recorded video or images so they can learn about the system in a timely manner.

4.2 HANDS-ON LABS

The hands-on labs are where students practice and improve their knowledge during solving real-world problems. By designing the visualization experience according to course schedule, it will provide students good supplement to textbooks.

Figure 4 shows the screenshot of a visualization lab which reconstruct social networks using their datasets, with appropriate algorithms, to reveal important social networks patterns. By selecting data type in the list on the left, and an algorithm on the right list, the system is able to display the social networking graph; in this case, community detection is used, then after clicking the "Generate" button, the graph with identified communities within it has been displayed.

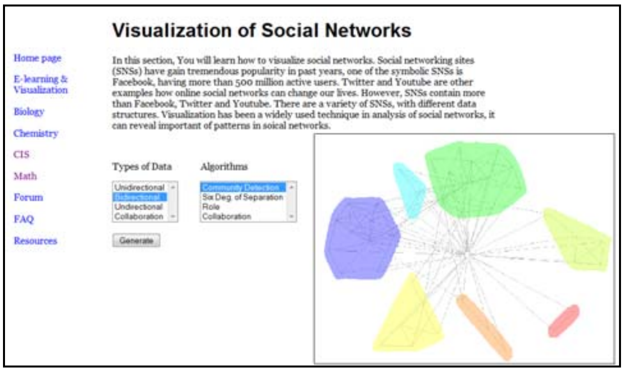

Fig. 4 Prototype of social network visualization page

Another case study is web-implemented Maxima. Maxima is an open source computer algebra system, which is usually installed on computers, either on Windows, Mac OS or Linux.

Our Computation for STEM Education project has involved Maxima as one of the teaching tools. During the use of this software, we have got response from the students about a variety of issue other than using the system. Installation is one of the most common problems. To solve it, we will implement Maxima on the website, so with a modern browser, anyone can take advantage of this powerful system without having to worry about installation.

As shown in figure 5, the web-implemented computer algebra system contains a main window, which takes input to it and then gives output, including graphs. By providing examples of the commands to students, and let them try the commands, it will not has a very sharp learning curve. The simple interface will not make students feel overwhelmed. But as one discovers more of the system, he or she will realize it can accomplish complicated work.

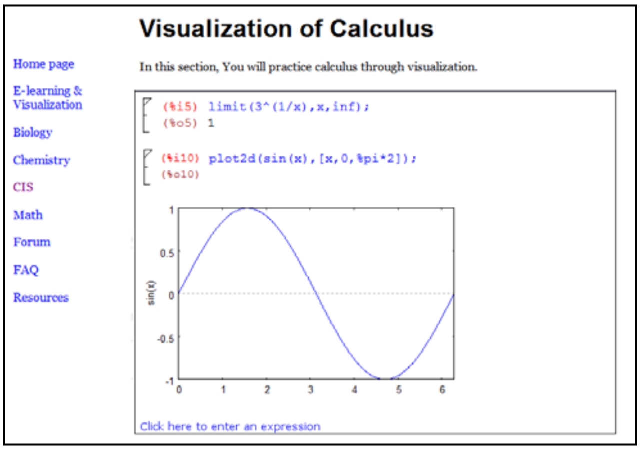

Fig. 5 Conceptual screen of a math algebra system based on Maxima

4.3 QUIZZES

Quizzes will incorporate visualization as well as general questions. Taking into consideration that general questions such as multiple choices or fill in the blank will conform to grading standards, they will be preferred types of questions. After taking quizzes, the results are evaluated and discover the weakness of students. The hands-on labs will be given for students to enhance the concepts until students master those concepts via hands-on labs.

4.4 SOCIAL LEARNING

One of the most important features of e-learning 2.0 is social learning, which assumes that the best way to learn something is to teach it to the others. The prosperity of social networking sites has met this demand. Open source social networking software has made it possible to create social networking sites with only a little effort.

The most important reason about creating a social learning networking site is that it is dedicated to the learning experience provided by the visualization site. Although tremendous commercial social networking sites are available, and almost all of them provide group discussion and other features, students will be reluctant to discuss academic problems within their social circles. A dedicated network will provide the convenience for their academic /professional needs. In such a virtual environment, students will be relaxed and ask or answer any questions while they can review repository of related questions and answers from previous semesters. In addition, such sites will be easily access from their social networks such as Facebook, MySpace.

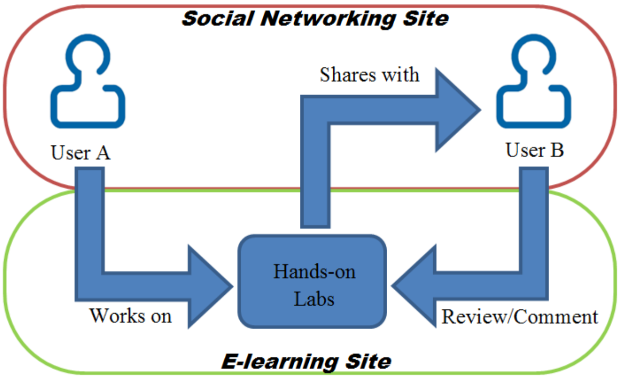

Fig. 6 Collaboration using the social learning features

Figure 6 demonstrates how a supportive social networking site can serve as a communicative platform for our e-learning framework. One of the great benefits from web 2.0 technology is users are allowed to join a social network and share all kinds of information among them. In this case, user A has doubts about a hands-on lab and asks user B for help by sharing current work with user B. After looking at the work, user B can review the work by giving comments. User B may be another current student, a previous student, or an instructor.

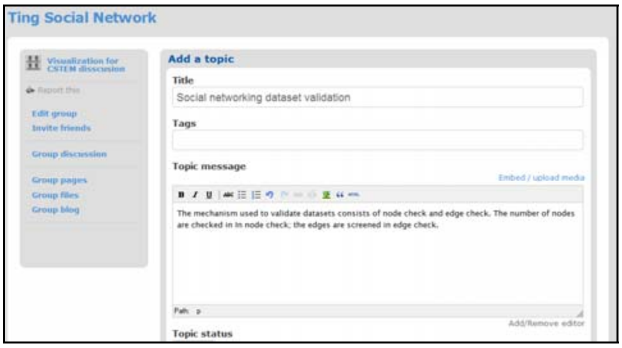

Fig. 7 Posting a discussion on the social networking site

As shown in figure 7, the social networking site has been set up using elgg social networking software. It provides group discussion and group blog pages. Each group can create their own blogs that are shared among all group members, but not to the public. See figure 8, in the access control a user is able to specify who will be able to view this blog post. This group blog setting ensures privacy and promotes efficiency.

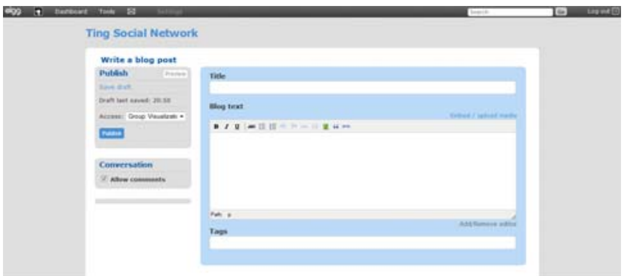

Fig. 8 Screenshot of posting a group blog in the Ting social network

4.5 DATA REPOSITORY

Visualizing experience requires data, for instance, to see how stock market goes, one needs historical stock data. A data repository will be built, which includes all the necessary data, such as social networking datasets, and biology genome datasets. Many types of data can be obtained from a variety of organizations, making real world based visualization possible.

5. CONCLUSION AND FUTURE WORK

Most current learning management systems fail to provide interactive visualization to the students, mere extensions of classroom activities will soon bore the students. Complicated systems are often research oriented; students will be overwhelmed by their interfaces, if the teaching material is not well-designed. This paper presents a novel web-based teaching environment, with the power of visualization and active learning. We do not target on providing tons of functions, just to offer what is really necessary for the course schedule.

Future work will include the completion of the visualization website, and adding various social forums to the social learning networking sites.

ACKNOWLEDGMENTS

This work has been supported in part by U.S. Department of Education grant P120A080094 and P120A090122.

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