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Effective Collaborative Learning in Biomedical Education Using a Web-Based Infrastructure

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Abstract— **This paper presents a feature-rich web-based system used for biomedical education at the undergraduate level. With the powerful groupware features provided by the wiki system, the instructors are able to establish a community-centered mentoring environment that capitalizes on local expertise to create a sense of online collaborative learning among students. The web-based infrastructure can help the instructors effectively organize and coordinate student research projects, and the groupware features may support the interactive activities, such as interpersonal communications and data sharing. The groupware features also provide the web-based system with a wide range of additional ways of organizing collaboratively developed materials, which makes it become an effective tool for online active learning. Students are able to learn the ability to work effectively in teams, with an improvement of project management, design collaboration, and technical writing skills. With the fruitful outcomes in recent years, it is positively thought that the web-based collaborative learning environment can perform an excellent shift away from the conventional instructor-centered teaching to community-centered collaborative learning in the undergraduate education.**

I. Introduction

The conventional college course teaching model is commonly featured by presentation of lectures, which provides an instructor-centered classroom teaching environment. The knowledge-based lectures tend to cover the materials in the same sequence as appeared in the textbook, but lack enough attention to interactive activities or learner involvement. Instead of just teaching new materials, recent biomedical courses focus much more on fostering the student ability of solving large-scale, open-ended, and sometimes ill-posed problems [1]. The aim of the courses have shifted to help prepare senior undergraduate students with the system-design, analytical, project management, and interpersonal skills [2], [3]. A typical syllabus would include fairly fewer lectures, and assess much on student problem-solving skills and teamwork collaboration performance. Students are required to provide their solutions to a practical problem with system-wide analysis, verbal project reports and written deliverable documents [4], [5].

The curriculum reform calls for the development of supporting information technology. Recently, the advances of learning science and internet infrastructure [6], [7] enable the instructors to effectively maintain the interactive mentoring materials [8], [9]. The web-based infrastructure provides convenient access to the supplement data and documents of research projects, at any time and from any where [10], [11]. In addition, the web-based learning environments can support online collaborations [12], [13], and their utility of powerful features enables the instructors to timely assess the student learning activities and performance [3], [14], [15]. This paper describes a feature-rich wiki system that was used in the biomedical education program offered by Xiamen University. We also present the advantages of the wiki-based collaborative learning environment for mentoring undergraduate students.

II. Teamwork Collaboration in Student Projects

Compliant with the program requirements of the Accreditation Board of Engineering and Technology (ABET) [16], the primary objectives of our student research-skill training courses are set to help prepare undergraduate students enrolled in the electrical engineering and bioengineering programs with the skills of teamwork, project concept generation, management, technical writing, and interpersonal communications.

Teamwork performance is positively considered to be a pivotal part in our courses. The class is usually divided into a few small teams, each of which includes less than four students. An interdisciplinary combination of students is highly encouraged in the class. Concerning the teamwork styles, the teams would be distinguished as field-independent or field-dependent categories [1]. Field-independent team members are defined as excellent problem solvers themselves, and they typically need private time to clarify ideas and solutions. Field-dependent learners, on the other hand, are defined as excellent communicators and need the interaction of the team to clarify ideas and solutions. In a team-based project, students have their individual tasks to accomplish, and a team success depends upon the members' contributions to the task completion as a whole.

An efficient teamwork collaboration requires an effective supporting environment as well. Recent studies on learning science, as summarized in the book of Bransford [17], reported that the most effective learning environments are

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those that are knowledge centered, assessment centered, learner centered, and community centered [8], [10], [18]. With the motivation of fostering collaborative learning in the undergraduate courses, we utilize a feature-rich wiki system, named "MediaWiki", to establish an effective community-centered learning environment to mentor students.

III. Collaborative Learning Using the MediaWiki system

A. Description of the MediaWiki system

Wiki is an emergent web-based system whose users can add, modify, or delete its content via a web browser using a simplified markup language or a rich-text editor. With the success of Wikipedia, wikis are typically powered by wiki software, and often created and modified collaboratively by multiple users. The MediaWiki is a scalable and server-based knowledge management system integrated with rich wiki features, which uses PHP to process and display data stored in a database, such as MySQL. Unlike other open source platforms that ship only a small set of features and encourage third party add-ons, the MediaWiki system already includes a number of features in the main code base, which helps ensure that the features will not get broken when the system is upgraded. The MediaWiki permits seamless integration of various extensions and makes the textual pages more powerful with additional functions. The MediaWiki can also manage image and multimedia (audio and video stream) files, which are stored in the filesystem with database records.

In the MediaWiki, the wiki syntax works throughout the application so that the MediaWiki can be used to facilitate community-centered collaborative manners. For large wikis with lots of users online simultaneously, the MediaWiki supports caching and can be easily coupled with Squid proxy server software. When a user submits a modification in a page, the MediaWiki writes it to the database, but without deleting the previous versions of the page, thus allowing easy reverts in case of vandalism or spamming. In addition, the wiki syntax features provide the MediaWiki system with a wide range of manners of organizing and monitoring collaboratively developed data (including forums, blogs, podcasts, and RSS feeds), which makes it become one of the most effective tools yet created for online teamwork and collaborations. An illustration of the MediaWiki system for our biomedical education at Xiamen University is shown in Figure 1.

B. Collaborative Learning Style in Biomedical Engineering Education

Using the MediaWiki environment for the mentoring of student research projects, the instructors can first post a few open-ended problems for students' choice. In this phase, the balance between theory and practice should be carefully considered. It is an art to define an appropriate problem for a student project. Generally speaking, too much "real world" practice would make the learning become simply job training, yet, too little practical experience leaves the students with naive problem-solving skills [1]. The problems selected in our biomedical courses can easily tap into students' interests and fall on a "reality" scale. These problems were not so trivial that they could be solved in only a few steps.

Later on, a series of lectures that address the details of projects and desired outcomes will be scheduled. The students can self-assess the project proposals, and also exchange their interests and ideas in the form of in-class brainstorming sessions or via web chatting with the MediaWiki system. At this stage, the instructors are coordinating teams based on the interests, capabilities, and backgrounds of students. According to our experience of successful senior projects in the past, the optimal team configuration often turns to be a combination of students with interdisciplinary backgrounds, and the team leaders should be sophisticated persons who are also good at interpersonal communications. The teamwork collaborations would be emphasized again, because the face-to-face talking and cyber-interactions among students are vital for the successful completion of their projects.

At the next step, the instructors can deploy the project assignments according to the conclusions of previous discussions, and help coordinate the team members involved in each project. The instructors will assist the students in focusing on the important aspects of the projects, along with guidance on research, technologies, methodologies, and testing. The research projects may include reviewing current literature on the subject, examination of current patents to see what has been done previously and what could be done without infringing on the work of others [14]. The supporting materials such as bibliography and technical notes are downloadable in the filesystem of the MediaWiki, and some illustrations and running project examples are visible on the wiki pages. The multimedia features of the MediaWiki enable the community-centered interactive activities by means of interpersonal communications and data sharing.

It is quite common that one or more students in a team are less industrious than others, which may result in an unsatisfactory project in the end. The timeline development, therefore, becomes important and necessary for a success of the project [19]. The MediaWiki system contains the Task feature which can help the instructors monitor the different stages of each ongoing project by reviewing the progress reports submitted by student teams via web browser. Students are required to make oral presentations about project implementation in class, and then submit written reports through the Article feature. The instructors will make comments on the task implementation and the interim reports, and might adjust the member roles within the unsatisfactory teams if necessary.

Finally, students will be required to upload their final reports via the stated website, which are comprised of team project deliverable documents and the individual contributions to their teams, in accordance with the deadlines indicated in the Calendar feature. Those project documents evaluated as an excellence will be posted on the web page, and a post-project meeting will be scheduled for students to present the strength and weakness of their projects. During the interactive sessions, the students can share their experi-

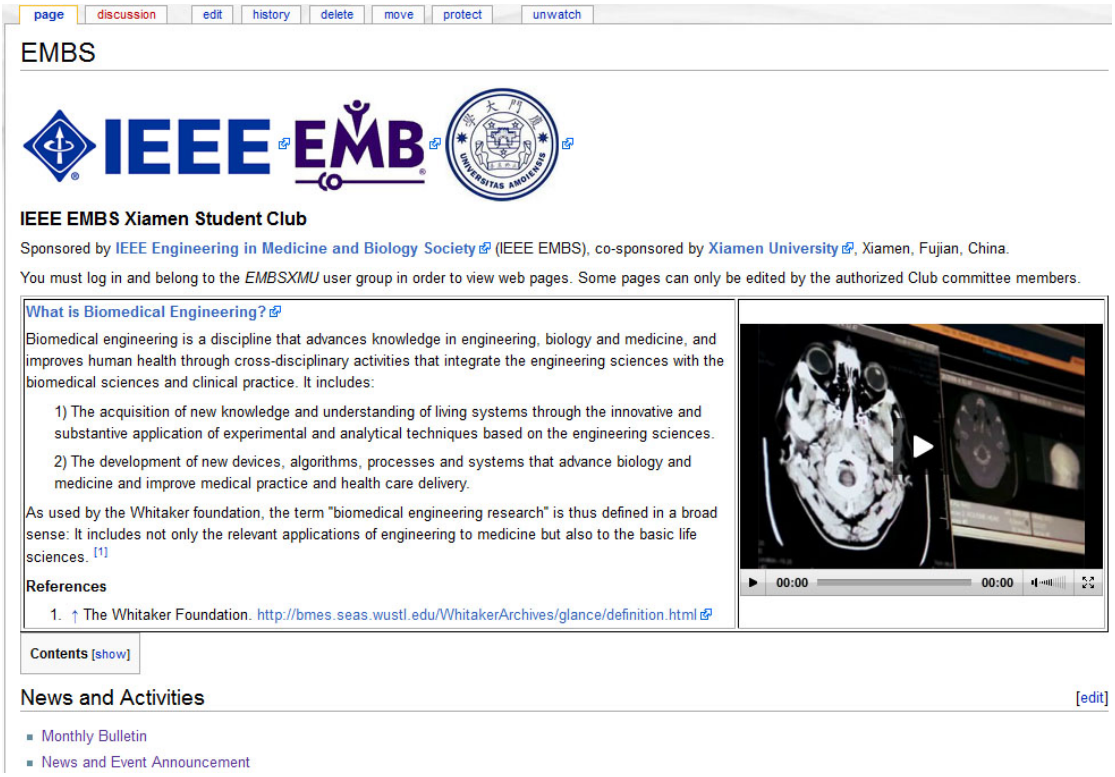

Fig. 1. The MediaWiki system used for biomedical education at Xiamen University: a snapshot

ence of project practice, and the instructors can summarize each project with informed advice. The session memos will be recorded by teaching assistants, and later archived in the course repertory of the MediaWiki system.

So far, we have assigned a number of student projects covering biomedical signal processing, biomechanics, and rehabilitation engineering. The topics included electrocardiogram (ECG) processing [20], breast cancer diagnosis [21], knee joint vibration signal analysis [22], [23], [24], [25], and gait analysis [26], [27], [28]. Some student projects have been supported by the research grants from the university or other institutions.

C. Student Scientific Contests and Professional Society Activities

The supplement elements to the student research-skill training courses are scientific contests and participation in professional activities. Students in our class were encouraged to level up their design projects for further student paper or design competitions, which follows the successful experience of Beijing University of Posts and Telecommunications [29], [30], [31], [32], [33]. Xiamen University also provides plenty of student grants to support the scientific contests. In each research grant, a student principal investigator was selected to be responsible for the completion of the project in one or two years, and the student teamwork should be supervised by their faculty advisor. In our student projects, the collaboration procedures were all carried out via the MediaWiki platform.

In addition, we arranged diverse professional activities, such as IEEE Distinguished Lectures, campus interdisciplinary selective course, and so forth, to improve the technical skills of the students. All of our student activities were organized by the IEEE EMBS Xiamen Student Club, and received sufficient financial supports from Xiamen University and IEEE Engineering in Medicine and Biology Society.

IV. Outcomes

The outcomes of our student mentoring based on the powerful MediaWiki system were fruitful. Our undergraduate students were awarded the Xiamen University Undergraduate Fundamental Innovation Research Grant, Xiamen University Undergraduate Student Innovative Experiment Project, and Xiamen University Undergraduate Innovation Training Project Grant. With the encouraging achievements, our students started efficient teamwork and online collaborations with the MediaWiki system. From 2010, our students have received 19 scholarships (four at national level). Fifteen junior undergraduate students were the recipients of the China's National Mathematical Modeling Contests and Interdisciplinary Contest in Modeling. The faculty advisor was also acknowledged with the university teaching excellence award. In addition, the IEEE EMBS Xiamen Student Club had been awarded the 2011 Best New Student Branch Chapter or Club Award recognized by the IEEE Engineering in Medicine and Biology Society.

V. Conclusion

It has been widely accepted that the collaborative learning activities can provide a unique opportunity to foster individualized learning and teamwork experience. Our web-based

MediaWiki environment performs a great shift away from the conventional instructor-driven mentoring to community-centered collaborative learning environment for biomedical education. Students are able to learn how to work effectively in teams, with a superb improvement of problem-solving skills, such as project management, design collaboration, conflict resolution, verbal presentation, and technical writing. It is believed that the knowledge-centered, learner-centered, and community-centered collaborative learning environment based on wiki or other web-based systems will play an important role in the pilot college programs, and provide students with good preparations for their future careers.

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