Adaptive Teaching for Large Classes

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Abstract *— This paper presents an innovative teaching method that effectively integrates IT technology into teaching and learning process. The new method uses adaptive technique to trace learners' performance during and after a lecture so that the educator is able to quickly adjust course contents to suit the needs of learners. The success of the method is based on two feedback loops established between learners and educator. The in-class feedback is created by a SMS message based quiz system and the after-class feedback is realized by an Educator-to-Learner Portal, e-Learning Hub [1], which provides information on learners' progress after a lecture. The intelligence of e-Learning Hub greatly reduces the workload of educators when deals with large number of learners. The new method brings a new learning experience to students in a learner centered environment.*

Index Terms *— Adaptive learning, Adaptive teaching, Teaching large classes, WWW based teaching.*

INTRODUCTION

Developing innovative teaching methods at institutes of higher eduction is encouraged at all time for those of educators who teach in them. However, it is much more desirable for developing innovative teaching methods for large classes due to increased enrolment every year. Teaching an overcrowded class is a very challenge task for educators due to many constrains imposed on such classes. We consider a class of more than 100 students is a large class. According to a survey done in Australia [2], some large classes in Australia contain more than 1000 students. How to create a learner centered enviornment and promote active learning among all students when there are so many students to deal with? The simplest answer is to break a large class into small classes. This is quite difficult due to economic constrains and traditional realites. The alternative is to support a serious attempt to improve the situation within the realistic.

Over the years, much effort has been made to understand the difficulties faced by educators in teaching large classes. These difficulties include encouraging class attendence, delivering well-balanced course contests to keep students' interest on subject, knowing students and creating interactive classes, identifying and making time to help students at risk, and getting/giving feedback and managing student inquiries. Many methods [3]-[6] are suggested to address these issuses. With the rapid development in communication and information technology, especially the Internet, it is possible to address these difficulties with the help of various existing technologies. The proper use of communication and information technology not only enhances the students learning experience but also maximizes student productivity. There are many existing web-based teaching methods [7]-[13]. Among them, the adaptive teaching method [11]-[13] is very interesting as it provides a machenism to personalize teaching for each student. The advantage of adaptive teaching is its ability to change the course contents according to students' needs. This is very useful for teaching engineering students. According to our observation, engineering students learn much better if the delieved course contents match their knowledge level. This is because large numbers of mathematical equations are normally used to model the real world problems and students need to put some efforts to appreciate the underlying concept. Although visualizing concept using multimedia technology helps students to understand the concept, the ability of an educator to delieve right amount of information to students is a key to successful learning. For a large class, educator will be able to teach more effectively if he knows what are the difficulties faced by students. To this end, feedback loops must be in place to keep track of students' progress during and after each lecture. In this paper, we present an adaptive teaching method that utilizes an intelligent learning portal to facilitate the learning and to maximize the effectiveness of a large class. The proposed adaptive teaching method uses a teaching and learning strategy comprised of two elements: in-class feedback and after-class feedback. The instant feedback loop creates an active learning environment within a classroom and an after-class feedback loop promotes other learning activities. These two elements allow educator to rapidly adjust course contents and to make classroom activities more efficient and more closely tuned to students' needs.

THE ADAPTIVE TEACHING METHOD

Adaptive teaching is a fairly new technique that utilizes the most recent information technology to enhance learning experience. It may be defined as optimal instruction that effectively meets the individual needs of the students and is conveyed toward a student's different aptitude i.e., intellectual abilities, personalities, and cognitive styles of learning [11]. If we classify a learning process into six levels [14], i.e. knowledge, comprehension, application, analysis, synthesis, and evaluation, the adaptive teaching is a great tool for improving learning process in the first two levels. It achieves these goals by implementing diagnostic and prescriptive instructional systems designed to make learning more effective, efficient and meaningful. Adaptive technique is widely used in control and digital signal processing systems to enhance performance of the systems. An example of such application is adaptive filter who improves the system's performance by adjusting its coefficients constantly to minimize the error between desired output and real output. Such an approach is very effective for performance enhancement in a dynamic system. The general principle of adaptive technique is to monitor the system closely and to adjust the system whenever there is a need to keep the system in the best condition. This principle can be applied to teaching and learning process to improve quality of learning.

The adaptive teaching pedagogy exploits interactions between learners and educator. Under proposed adaptive teaching method, an educator prepares two sets of carefully constructed assignments, one for in-class test and another for after-class activities. The in-class quizzes aim to test students' understanding during a lecture and the after-class activities are to engage the students with other learning activities. During a lecture, an educator will give students a quiz whenever there is a need to check students' understand on a given topic. Students will answer the quiz questions by sending a SMS message to an instant feedback system that will be detailed in the next section. The instant feedback system will automatically grade students' answers and display a statistic bar chart for viewing by the educator. From the instant feedback, the educator can address student's difficulties immediately and adjust the course contents accordingly to suit students' needs. After the lecture, students will log on to an adaptive teaching web site to complete the assignments at their own pace that are due a few hours before next lecture. The educator reads the student online submissions to adjust the content and activities for next lecture to maximize the gain for students. It is obvious that adaptive teaching will bring the benefits to both learner and educator. To the students, they come to class prepared and already engaged with the material as the after-class feedback loop helps them to identify their weakness. To the educator, he always knows exactly where the students are and what problems they have, so that he can be more focused during a lecture.

The success of such a method relies on two feedback loops established during and after a lecture. By creating these two feedback loops, adaptive teaching greatly enhances the learning efficiency. The role of feedback in any learning environment is clearly important. It provides two main functions; first, it helps educator to know what difficulties students may face in their learning process. With this information, the educators will be in a good position to help the students to overcome their difficulties. Second, it allows student to find out their weakness, so the student is engaged in the learning process. The instant feedback loop serves the purpose of information collection that helps the educator to address student's immediate concerns. It has three advantages: first, the educator is able to teach according students' need. Often times we teach a course based on our experience and use previous batches of students as a reference. This approach gives us a rough idea on students' learning pattern. But each batch of the students may learn differently. We found that the students from computer engineering learn quite different from the electrical engineering students, so as the junior and senior students. With the increased diversity of the student population, not only in race and culture, but also in age, our experience may not work well. The instant feedback loop let us know exactly what happens among the students, so we can address their problems instantaneously. Second, the students know their problems immediately. It is quite often that the students seem to understand the new concept, but they are at lost when ask them to apply it. The in-class quiz helps the students to identify their problems and weakness, so that they will be engaged in the learning and become an active learner. Third, the system acts as a tracking mechanism to monitor the students' performance. Each time a student responding to a quiz, the system keeps a record. At the end of quiz, the system generates a report on each student. The report includes the performance of the student during all lectures. The educator can set a threshold to allow the system to alert on weak students.

The after-class feedback loop plays another important role in the learning process. The instant feedback loop addresses the issues in the first two learning levels, i.e. knowledge and comprehension. The after-class feedback loop extends learning to additional two levels, application and analysis. This is done through an enhanced intelligent Educator-to-Learner portal [1],[15], *e-Learning Hub*. The *e-Learning Hub* solves two major problems faced by the educators, students' performance tracking and knowledge transfer. As the adaptive teaching requires an educator to know students progress between two lectures, it puts a lot of pressure on the educator as he has to analyze all feedbacks in a very short time frame, normally a couple of hours before the lecture. The task becomes mission impossible if a class involves several hundreds of students. One of the ways to solve this problem is to limit tutorial/assignment to multiple-choices questions (MCQs) or questions with numerical answers, so that a computer program can mark the solutions automatically and generate the statistic data on time. Unfortunately, this method is not quite suitable for many engineering courses especially for advanced courses in

undergraduate study and graduate-level courses. This is because the tutorial/assignment in advanced engineering courses tends to use symbolic or graphic-based answers. With the *e-Learning Hub*, students are able to get instant feedback on whether their symbolic solution to a problem is correct or wrong. Their performances are recorded by *e-Learning Hub* and presented to the educator at anytime. The workload of educators is greatly reduced.

Knowledge transfer is another important element in engineering education. It not only trains the students on application and analysis skills but also stimulates student's creativity. While a single sentence and mathematical answer is always possible for a specific tutorial question, it is highly appreciated if students can carry out a reasoned simulation before answer the question. MatLab is such a tool that is capable of such a simulation for many electrical engineering topics, but the learning curve involved in understanding the tool can distract a student from trying to adopt it. To encourage students to do more hands-on and cultivates students' interest in a subject, a web-based virtual simulation tool that allows student to access it from anywhere anytime is included in *e-Learning Hub*. Currently *e-Learning Hub* supports topics in digital signal processing and integrated circuits design. In a digital signal processing course, the ability to develop digital signal processing algorithms becomes important part for students when they go deeper into the world of digital signal processing. A web-based virtual laboratory was developed for this purpose that trains the students in developing digital signal processing algorithms.

Until now, we have presented the essential part of the proposed adaptive teaching method. To make it successful in a large class, a supporting tool is absolutely necessary. An enhanced Educator-to-Learner portal is developed for this purpose.

THE SUPPORTING TOOL

In the proposed adaptive teaching method, two types of feedback loops should be established to gather the information on the students' progress, an instant feedback loop and an after-class feedback loop. An instant feedback can be carried out in a form of in-class quiz for a small class. But it is very difficult to adopt such an approach in a large class as there is no time to mark all answers during the lecture. In our practice, the instant feedback is achieved by using SMS messaging service provided by mobile phone. The selection of SMS messaging service as instant feedback tool has two advantages. First of all, it is most cost effective way to gather instant feedback and is easily to integrate with a web-based system. The service is highly reliable as it is provided by Telco. Other rapid feedback systems require heavy investment on hardware, such as voting systems. These systems lack of flexibility as they can not move around once installed. Although a wireless based voting system provides flexible solution, its cost is too high and it is difficult to maintain. With the increasing population of the mobile phone, we found that more than half of our students bring mobile phone to the class. This makes a SMS message based instant feedback feasible. Secondly, the students are very familiar with SMS service. They are very excited when such a service is applied to learning. Our observation shows that students are much more active in using SMS service than traditional in-class probing. We even use such a system to conduct competitions during the second hour of lecture. The system is able to display a list of students whose answers are correct according to receiving time stamp. This is very helpful to bring the students' attention to the topic. Figures 1 and 2 show the interfaces of the instant feedback system at the *e-Learning Hub*.

FIGURE 1. A SMS QUIZ

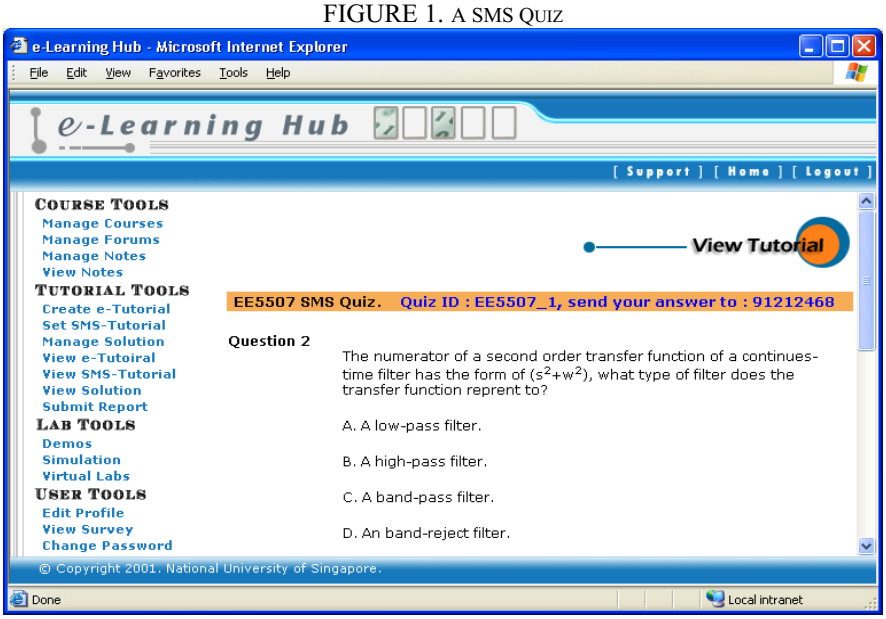
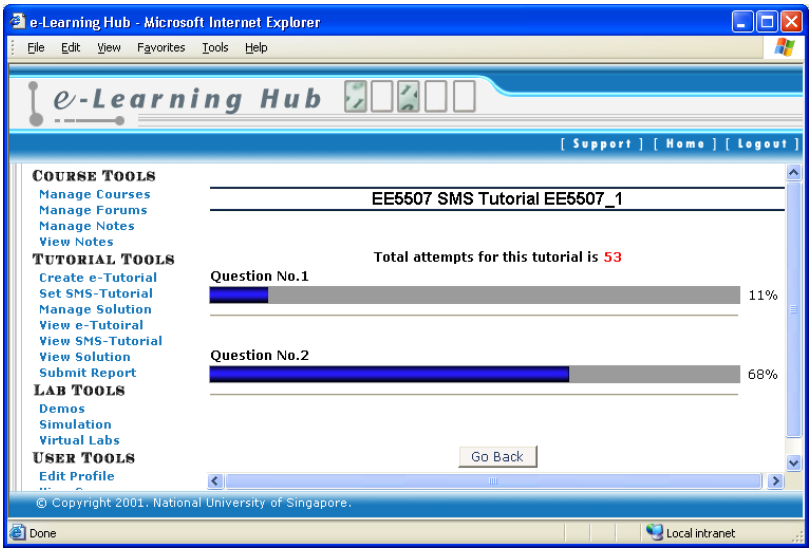
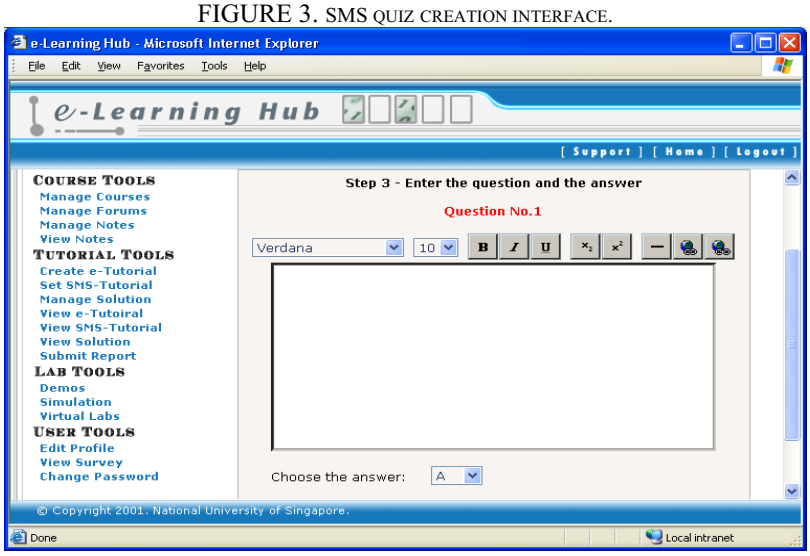


FIGURE 2. A SNAPSHOT OF EDUCATOR'S VIEW FOR STATITIC BAR CHAR



The instant feedback system is able to publish two types of quiz, multiple choices question and the question with numeric answers. In order to make the quiz creation process as simplistic as possible, one important consideration in creating the interface for the SMS quiz input is to ensure it is user-friendly, simple to use and provides What-You-See-Is-What-You-Get effect. To reduce the learning curve, the quiz creation interface is designed in a manner similar to text editing in word processors as shown in Figure 3.

FIGURE 3. SMS QUIZ CREATION INTERFACE.



The instant feedback system is designed for all students. It does not leave out the students without a mobile phone. The input to the quiz contains three fields, a course code, answers to questions, and an optional user login name. If a student uses a mobile phone other than the one registered, he will need to enter the user login name in the third field. At the beginning of the class, each student requires to create an account at the Educator-to-Learner portal, *e-Learning Hub* that includes the instant feedback system. The student is required to register their mobile phone number if he has one. When the student enters his answers, the system will automatically identify the student and keep a record of his answer. For the student without a

mobile phone, there are two alternatives, he can borrow a mobile phone from others in the class or make use of the *e-Learning Hub* or any Telco's SMS website to enter the answers after the class.

The after-class feedback loop is established through the use of an intelligent Educator-to-Learner portal, *e-Learning Hub*. The *e-Learning Hub* contains following functions:

- Multimedia demonstrations on difficult concepts.
- Visualization tools for exploring the difficult concepts.
- An intelligent tutorial system that is able to grade students' answers automatically. Currently it supports four types of questions, multiple choices question, numeric question, symbolic question, and question with simple graphic answer. For symbolic answers, the system is able to tell whether student's answer is correct or wrong if it is in a format different from the standard answer, e.g. the standard answer to a question is ————, the system will be able to tell that the following answers, ——— ——— ——, are all correct.
- Virtual simulation tools that allow students to carry on simulations at anytime from anywhere.
- Virtual lab tools that allow students to conduct experiments using a web browser.

Figures 4-6 show some of the interfaces of *e-Learning Hub*. Detailed information about the *e-Learning Hub* can be found in [1] and [15].

FIGURE 4. INTELLIGENT TUTORIAL SYSTEM WITH AUTO-DIAGNOSIS

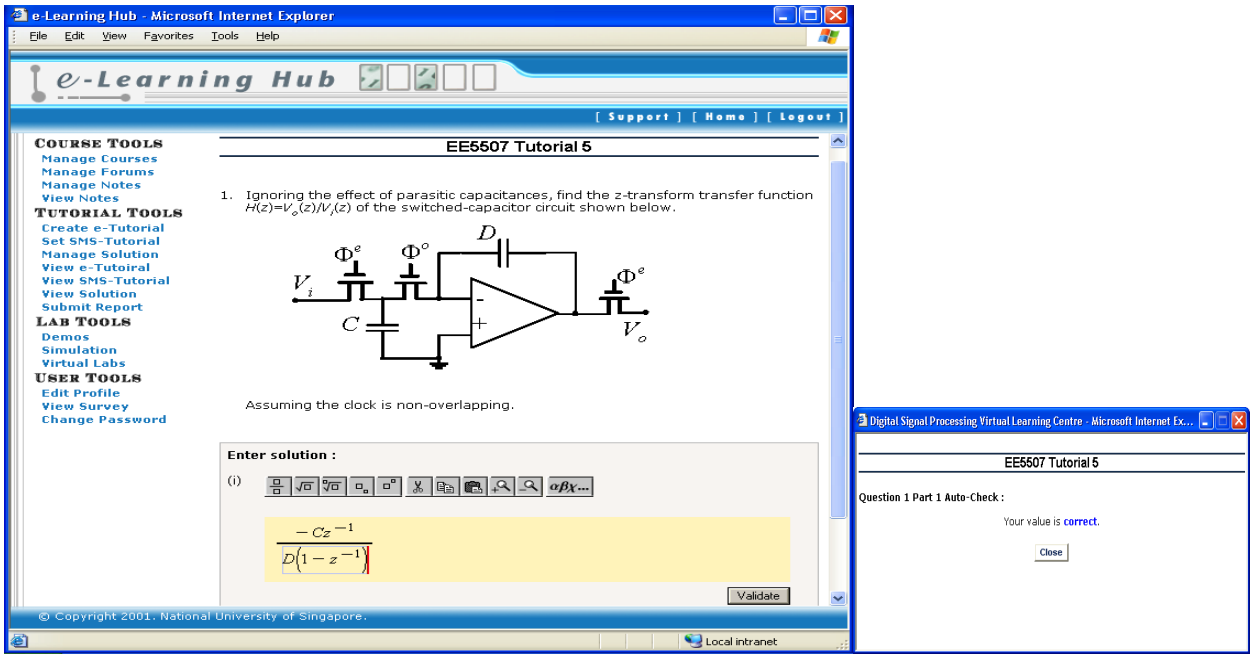
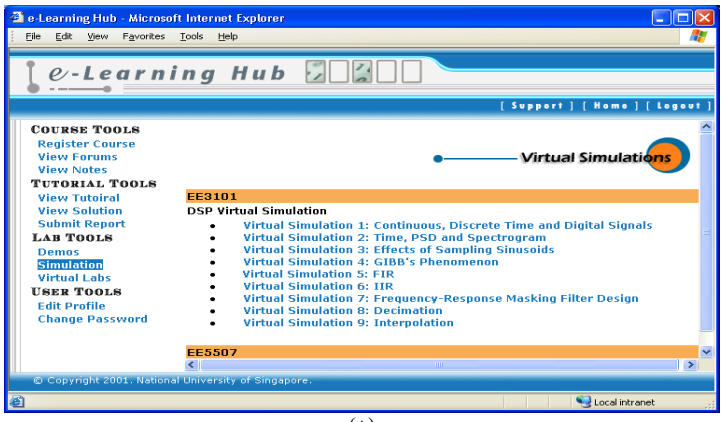
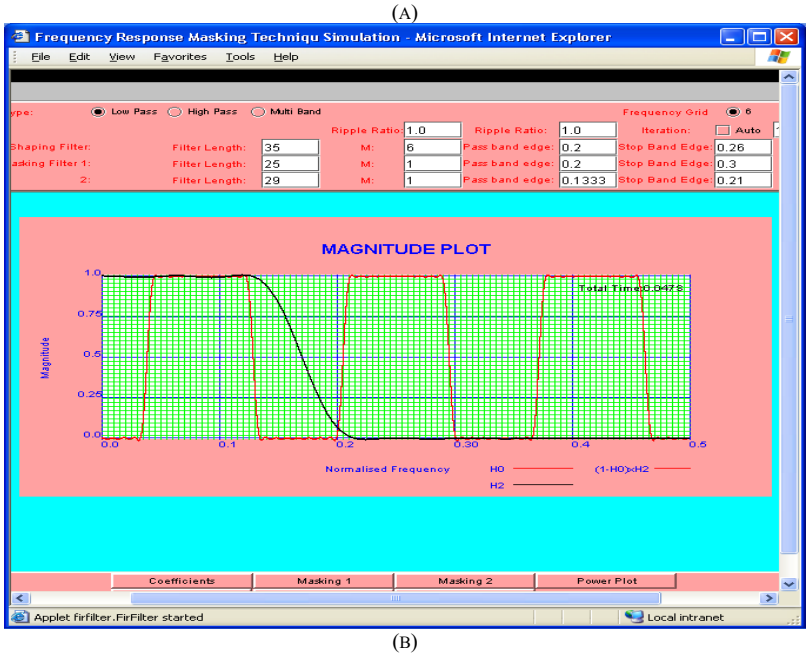


FIGURE 5. (A) VIRTUAL SIMULATION USER INTERFACE; (B) FILTER DESIGN SIMULATION.

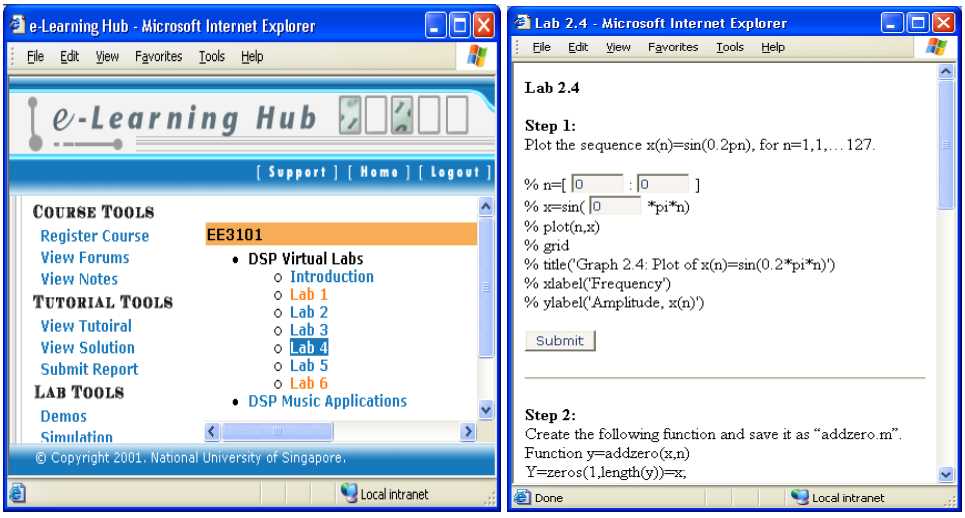


(A)



(B)

FIGURE 6. VIRTUAL LAB USER INTERFACE AND AN EXAMPLE OF GUIDED LAB.



CONCLUSION

We have presented an adaptive teaching method that is well suited for teaching large classes. The proposed method is based on adaptive technique that is able to continuously monitor learners' progress during and after a lecture. Two feedback loops are established to keep track of students' performance. The in-class feedback is achieved using a SMS messaging service provided by mobile phone and the after-class feedback is done through an enhanced Education-to-Learner portal, *e-Learning Hub*. With two feedback loops in place, the educator is able to deliver well-balanced course contents that match the students' knowledge level. By doing so, it makes learning more effective, efficient and meaningful.

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REFERENCES

[1] Lian Y., and Tan Y.H., "An Educator-to-Learner Portal for Just-in-Time Teaching", *Second Symposium on Teaching and Learning in Higher Education*, 2002, pp.420-425.

[2] Herbert D., and Hannam R., "Report on Survey of Large Class Teaching in Australia", *http://www.tedi.uq.edu.au/largeclasses/pdfs/Resources_2ReportonSurvey.pdf*, Teaching and Educational Development Institute, The University of Queensland, Australia.

[3] Teaching Large Classes, Part V, Suggestion for Further Reading, *http://www.uwo.ca/edo/tlc/lc_part5.html*, Educational Development Office, The University of Western Ontario.

[4] Johnson R. N, Enerson D. M. and Plank K. M., "Selected Bibliography for Teaching Large Classes", *http://www.psu.edu/celt/largeclass/lcbib.html*, Center for Excellence in Learning and Teaching, The Pennsylvania State University.

[5] Gibbs G., and Jenkins A., "Teaching Large Classes in Higher Education", London : Kegan Paul, 1992.

[6] Carbone E., "Teaching Large Classes: Tools and Strategies", SAGE Publications, 1998.

[7] Lian Y., "Learning Digital Signal Processing at Six Degrees of Freedom", *Second Symposium on Teaching and Learning in Higher Education*, 2002, pp.444-449.

[8] Novak G.M., Patterson E.T., Gavrin A.D., and Christian W., *Just-in-time Teaching : Blending Active Learning with Web Technology*, Prentice Hall, 1999.

[9] CoLos Main Entry Page[Internet]. http://www.colos.ec-lyon.fr

[10] J. Shaffer, J. Hamaker, and J. Picone, "Visualization of Signal Processing Concepts", *The Proceedings of 1998 International Conference on Acoustics, Speech, and Signal Processing*, **3**, 1998, pp.1853-1856.

[11] Srisethanil C., "ITS-Engineering : Providing Adaptive Teaching in the Engineering Tutor", *Frontiers in Education: Engineering Education for the 21st Century*, November, 1995.

[12] Specht M., and Oppermann R., "ATS-Adaptive Teaching System a WWW-based ITS", *The Proceedings of Workshop Adaptivitt und Benutzermodellierung in Interaktiven Softwaresystemen*, 1998.

[13] Barbara H.R. "Adaptive Learning Guides", *The Proceedings of the IASTED Conference on Computers and Advanced Technology in Education,* Banff, Canada, June, 2001.

[14] Wills S., McNaught, C., "Evaluation of Computer-Based Learning in Higher Education", *Journal of Computing in Higher Education,* vol.7, no.2, 1996, pp. 106-128.

[15] Lian Y., and Hu B., "An Intelligent Learning Portal for Distance Learning", *The Proceedings of 2003 International Conference on Engineering Education,* Valencia, Spain, 21-25 July 2003.