Basic Support for Ubiquitous Learning Environment in the University

Hiroaki Ogata, Nobuji A. Saito, Rosa G. Paredes J., Chengiu Yin, and Yoneo Yano
University of Tokushima, Japan
ogata@is.tokushima-u.ac.jp

Abstract

In this paper we present our ongoing research about the integration of ubiquitous computing systems into classroom settings, in order to give basic support for some classroom and field activities. We have developed some web application components using Java technology and configured a classroom with wireless network access and a web camera for our purposes. In this classroom the students interact between them and with the professor through an Internet enabled PDA, using the different modules described in this paper. We include our evaluations about the performance and usability of the system in a computer science related course of the University of Tokushima, other practical uses and the future research and development work.

1. Introduction

The continuing advances in the wireless network communications field and the materialization of smaller portable computing devices, [11] have opened a new branch of research and development in the computer supported learning area, resulting in mobile learning tools using next-generation devices [7, 5, 9] Furthermore, the transport capability of the new learning environments has made possible to support classroom and field activities with different devices such as Tablet PCs, PDA, cellular phones, etc. [6, 8, 3].

Computer Supported Ubiquitous Learning (CSUL) is defined as supporting the teaching/learning process using embedded and invisible computers in everyday life [7]. This represents the intersection between the application of e-learning environments and mobile computing technologies, allowing effective anytime and anywhere learning experience. CSUL enables the access to different information networks in the precise moment that is required to inquire any search, providing the learners with information in different formats and representations like advices from teacher and/or experts on demand [10]. CSUL implies new and different ways of interaction between learners, tutors and materials. For this reason many authors agree that the challenge in this field for the next years is to find which learning patterns can be effectively supported [4, 13].

Generally speaking the use of mobile devices for supporting the classroom activities has reported good results in different early evaluations [3]. New technological advances have created diverse means of interaction with computers. Nevertheless it is still not completely clear which learning activities or patterns are the ideal scenarios for integrating ubiquitous computing support. The reason is that sometimes, the application of technology cannot be naturally “embedded” into the learner's activities, and only disturbs him/her, delaying the learning process and limiting the user’s freedom.

Nowadays it is possible to say that in the upcoming years, it will become familiar that students bring some mobile device into the classroom, as an embedded tool for supporting his/her learning process, in the same way a pencil, a ruler or a calculator does [5], in spite of some reluctance from traditional teachers. From the personal experience of many academic specialists, we realized that generally in traditional pedagogical models, during classroom time, there are some unnecessary tasks involved that can be automated in order to enhance the teaching/learning process. These tasks include the attendance list, the distribution of class materials (documents, exercises, and tests), report submission and grade, etc. In addition, students tend to hesitate to make questions in the classroom due to social inhibitions. Therefore it is necessary to model new learning patterns for classroom activities, and to develop the software components that support these new models. In this research we want to analyze the feasibility, opportunities and challenges involved in the application of a ubiquitous learning system in classroom activities.

2. BSUL Environment

The BSUL (Basic Support for Ubiquitous Learning) Environment, proposed and described in this paper, presents several characteristics and functionalities that aim to support the learning process inside and outside the classroom:

Reducing time-consuming tasks: Classroom activities include some frequent, tedious and redundant tasks. For instance, teachers take students' attendance, give students exercises and test sheets and collect the results when students finish their work; or ask students to rewrite and/or demonstrate their completed assignment in front of the rest of the class on a whiteboard. Such procedure occurs quite often in regular classrooms, consumes much time and interrupts the ongoing teaching activity flow.

Augmenting interaction: In traditional classrooms there are a limited number of learning materials and hence students don't have enough assets to relate the course contents with external sources. Our proposed classroom provides full connectivity to the Internet, consequently every student can use his/her PDA to explore, collect, discover and annotate online resources in order to complete the class assignments collaboratively in a controlled workspace. Teachers can assign quizzes, surveys, and polls during class, for the students to answer using their PDA, and in the event that they had a question, teacher or teacher assistants can reply individually on the spot or after the class.

Recording teaching and learning processes as portfolios: Learning material, quizzes and tests created by the teachers, as well as the reports and assigned task submitted by the students are recorded in individual or group archives. These records provide with a nice repository to encourage and promote the teachers' and students' reflection, becoming aware of their overall performance.

Fostering collaborative learning: During group activities teachers have to face two important problems: First students' interaction is based mostly in the exchange of ideas verbally and this process could not be recorded. This simple problem forces these activities to be regarded as goal/result oriented, instead of process oriented, and the process of discussion and deliberation is indeed an important one that should be recorded for future reflection. The second problem refers to the inherent problems related to the creation of effective learning groups. For instance in any given group activity, the high ability students in a group tend to dominate the whole activity, not allowing other members to benefit from all the learning opportunities. The BSUL environment contains a learner model component that helps the teacher in the configuration of learning groups based upon the students' interest and capabilities, allowing to create balanced groups where the members can get along upon shared interests.

Synchronous and asynchronous interaction support: Students can review learning materials and video of the lecture contents in an asynchronous way when the class has finished, and from remote places. Moreover, the students can remotely use some of the modules of the environment, giving them some interaction possibilities to some extent.

We set up a classroom with 3 wireless network access points (WIFI IEEE 802.11b standard) controllable web camera to stream the video feed of the class contents, a presentation screen, light projector and one Pocket PC PDA for each student (Fig. 1). Since the use of WIFI connectivity, has a high battery consumption rate, PDA cradles are conveniently located over the students' desktop, for recharging whenever needed. The PDA has Internet connectivity even outside of the classroom in neighboring buildings, hence the possibility to organize dynamic activities beyond the classroom space restrictions.

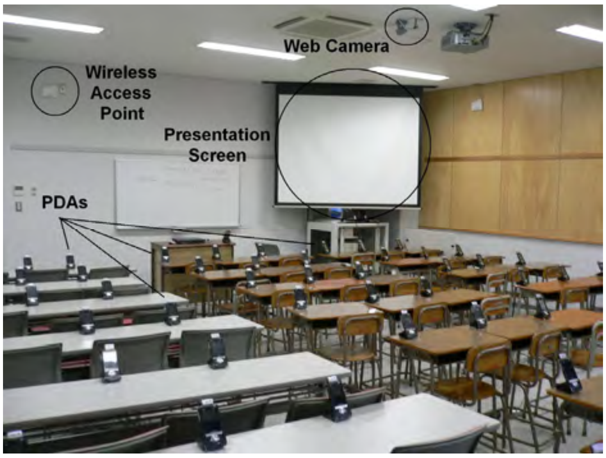

Fig 1. BSUL in the classroom.

2.1 Technical details

This environment was modeled following the standard specifications of Java 2 Platform, Enterprise Edition (J2EE), implementing different software patterns, like Model-View-Controller (MVC). We chose this architecture because the re-usability of components and the previous experience developing web applications under this specification [1] In addition, we are planning to use this system with numerous concurrent users, thus we needed a server framework that supports distributed applications. In order to make use of the modules of the environment, the client device (PDA, Tablet PC, laptop or desktop computer) needs a fully compliant web-browser.

2.2 Courses and Material Management

The main purpose of this module is to enable the teacher, assistants and system administrators to make the different course management tasks such as creation of courses, students' registration, material upload, etc. The teacher creates a course and registers the students in it, and then he/she can start uploading material for each class session.

2.3 Report Submission

Using the same web application, the teacher can assign reports for every course, giving the title, description and deadline for the assignment. The students submit their reports, through the web application by uploading the file into the main server. Finally the teacher grades the submitted reports and the students can view their grades on-line.

2.4 Attendance Taking

The attendance list system is a support module, based on the RFID technology (Radio frequency identification). [12]. For the attendance taking module, every student has a RFID tag and when he/she enter the classroom the system reads the RFID tag and sends a message to a web service based on the SOAP (Simple Object Access Protocol) asking to update the system database. We have proposed 4 different statuses for the students: Attendance, absence, delay and a fourth one called remote attendance, which means that the student is viewing the contents of the class through the streaming video source. The criteria for deciding whether a student is late or not, can be configured by the teacher in charge of each course. For instance, in most courses, the students have 10 minutes of tolerance, from the beginning of every class session, before they get a delay attendance status. The teacher can view the records of each student's attendance during the course using the environment web site, but the students can only view their own records.

2.5 Feedback System

The feedback system allows the students to make questions to the teacher in the moment they face something they don't understand during class or outside the classroom, supporting assessment on-demand [5, 7]. The students can make question in a freely, anonymous way using the PDA. When the class is over, the students have to store their level of understanding about the class. The level of understanding is a numerical value from 0 to 10 that represents how much the student thinks he has understood the class. This value helps the teacher to monitor the students' performance and evaluate his/her own performance as well. Using the feedback system, students are able to submit their questions or ask for help from the teacher or other students while reviewing class materials, or submitting their reports.

2.6 Response System

A classroom response system can be defined as a tool that allows the teacher to obtain responses from the students about surveys, polls or small tests. The system can recollect the students' answers and if applicable, create tables, histograms or any other graphs, supporting the teacher's awareness about the students' individual performance and general misconceptions. Alone by itself, it may sound an uninteresting application, but it has obtained many good results in practice, improving the students' participation and commitment in class [9, 6]. In the BSUL environment, the teacher uses a given application to create a set of questions represented in XML format.

During class, the students answer the surveys using their mobile devices, and the system creates statistics with their answers. These statistics also include information about the number of students that answered with the right option, and can be reviewed later, to support the teacher's awareness about the students' performance and understanding (Fig. 2). For multiple-choice surveys, it is possible to assign a correct answer to each question, making possible to grade instantly the results of each student. If a student wants to know the correct answer of any question that he/she failed, the system can offer the list of some students that got it right. The surveys can be created with two purposes on mind: to know the capabilities of the learner, or his/her personal interests. Capabilities and interest are recorded individually in every student's learner model and are regarded as key information for establishing the criteria for group configuration.

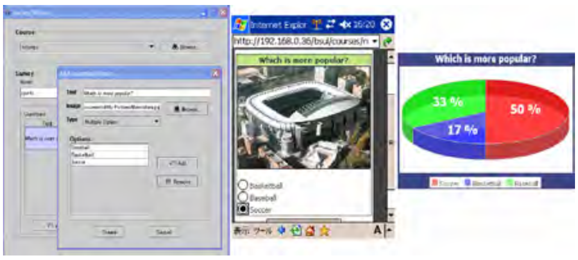

Fig. 2. Response System.

2.7 Learner Model

The learner model allows the personalization of the environment and allows keeping track of the user's interaction history, personal information, capabilities, interests, the client's hardware and software specifications, etc. Currently we are using a generic user model server for this purpose [6, 2]. This is an external component with a multi-model approach, that helps not only to reduce the amount of information that the server has to process at a given time, by allowing the applications to work with all the model or only with a restricted part of it, but also to increase the reusability of the model itself. Each sub-model is described as follows (Fig. 4):

(1)Application model

The application model is compounded by the particular modeling knowledge of the applications, and is divided as follows:

· Access information, to verify and regulate the permissions granted to the applications to register themselves for using the services of the system, and it will be required by the toolkit for establishing communication. By doing this, we are trying to assure the consistency and privacy of the application's information.

· Constants, the values predefined by the application for the thresholds that will be used for evaluating the beliefs maintained in the models. The application can modify these values at anytime, to further regulate the behavior of its models.

· Stereotypes, the classification of the identified homogenous characteristics among subgroups of users. This may be used later for assigning a standard model to new users, which is composed of common information retrieved from the models of other users in the same category that have previously interacted with the system. As the application begins interacting with the new users, more accurate assumptions can be made, and their models will be gradually modified [6, 13].

· Triggers, changes to be made to the model when it reaches a state that satisfies the predefined conditions. Repetitive changes that the application may want to perform to the models should be included here. For example, if a user has the commitment to attend to a meeting, and the las time that the user logged in the system was registered during the scheduled time, then the location of the user could be set to the same location where the meeting is taking place.

(2) User model

The user model is considered to be a set of beliefs that the system has about a specific user, and we have represented it through probabilistic values assigned to those beliefs. The probabilistic values are calculated using the mathematical approach proposed by Ayala & Paredes [1]. The following elements are regarded as relevant for this model:

· Personal information to identify the user, such as name, e-mail address, age, gender, nationality, address, etc.

· Experience information about his/her capacities and abilities, spoken languages and educational background.

· Interests and intentions, including his/her commitments to others.

· Stereotype assigned according to the characteristics defined for the classification established in the application model.

The information in this model is either provided directly by the user, or inferred through the interaction with the system, and for the first case the information must be sent by the application, either complete or by parts, through the toolkit interface. Several applications that contribute in the generation or maintenance of a group of models should be careful when making any modification, and remember that their requests are attended in the same order in which are received.

(3) Usage model

The usage model is a representation of the behavior history of the user interaction [12], and we have separated it in two different logs:

· Access logs, used to obtain information about the usage frequency and regularities, such as: How many times? When was the last time? When does s/he usually access?

· Action logs. We take in consideration three kinds of actions, selective (such as following a link on a web page, linking a resource or printing a file), confirmatory (book marking a page, saving or downloading a document), and disconfirmatory (deleting a file, erasing a page from his/her bookmarks). Other actions that fall into these categories may be aggregated by the applications when considered valuable information as well.

(4) Environment model

The environment model comprises data about the situational context in which the user is engaged. According to Roschelle [14], in the same physical space in which learning is taking place there is an overlaid network of wireless devices, and in order to relate the learner and his/her surrounding environment we have to represent the characteristics of both. In our representation, the environment model consists of 3 elements:

· Hardware information, such as processing speed, accessible input and display devices. Basically, promotes the terminal personalization for the user's device. For example, if the display of the device is small, the application could redirect the user to a smaller interface, or restrict the use of complex functionalities that consume more resources.

· Software information, including version, platform or available plug-ins. Before running a program or displaying a file, applications could verify if the device's installed software is capable of executing the action, otherwise prompting the user to install it.

· Location information, about the physical place, the objects at hand and other users located in the same area. This will contribute with a better insight of people and objects located around the user that could establish an interaction with him/her. One example of this could be an application whose users are supposed to do a cooperative work, and the best matches for the teams are decided by searching people in a nearby spatial location.

(5) Toolkit

The toolkit is the component that interacts directly with the models, and provides an entrance point to the applications. We decided to have an extra component to give mobility and flexibility to the system. For its implementation we used Java programming language and followed the J2EE (Java 2 Platform, Enterprise Edition) specification, which supports the development of reusable components as well as the integrated data interchange using XML-based open standards and protocols. The toolkit has two interfaces, acting as:

· A remote endpoint that can be accessed through RMI (Remote Method Invocation) by applications programmed in Java.

A web service endpoint that can be accessed through the SOAP protocol by applications developed using other programming l

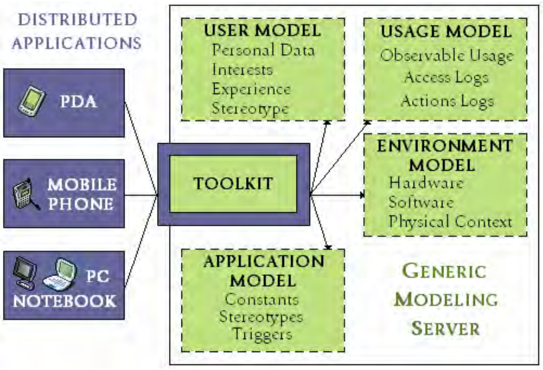

Fig. 3: Generic Modeling server

Aside from personalization purposes, the learner model assists the teacher in the configuration of discussion groups, according to the students' interests, capabilities or a combination of both. The teacher can propose any group activity, and distribute the students in any desired number of groups that can be configured according to the importance of interests' affinity and sum of overall capabilities. Under some circumstances the teacher should require the groups to have homogeneous interests to promote the rapid integration of the members; or the groups need to have balanced capabilities in order to be able to fulfill the task at hand.

3. Experiments

During the second semester of 2004 we evaluated the BSUL environment in a course of the University of Tokushima. The course contents were related to Computer Assisted Instruction and the learners were all computer science master degree students. Usually in this course, the teacher gives a presentation about the subject, generally using Microsoft PowerPoint presentations, distributes other required printed materials, and keeps low interaction with the students, who are passive information receptors. From time to time, the students are asked to write small reports during class or participate in surveys about their opinion about certain topics. In this course, the students' attendance is an important factor for the final semester grade, but due to the big number of enrolled students, the attendance taking is a time consuming task. Furthermore, in every class session, the teacher makes references to different materials and all the students need to have access to these materials, normally electronic versions. Outside the classroom the students need to be able to review previous classes, discuss with their classmates and submit reports to the teacher.

We divided the evaluation process in three sessions of around 90 minutes: During the first session the students learned about how to access the system and interact with the modules of the environment. Most of the students were not familiar with the usage of the Pocket PC operating system, and especially with the text input interface.

In the second session the teacher uploaded some material and the learners were able to browse the contents successfully. Along the class the teacher made use of the response system to make the students more participative in the classroom.

For the third session, 20 students were selected randomly and asked to leave the classroom to take remote attendance from a different place. These students used the stream video source to watch and listen to the class contents and remotely downloaded the materials. Both the students in the classroom and the remote attendees had to answer to some small tests created using the response system.

Concerning the performance of the system, we obtained satisfying results with around 40 users concurrently, downloading material, visualizing the contents, and answering the surveys. However the students that remotely attended the class found a little difficult to interact with the system while viewing the stream video at the same time. In addition, the delay in the streaming video was not a substantial drawback; however, in order to provide shorter buffering and load times, the video quality was not as good as desired.

At the end of the last session, we took a questionnaire using the same response system to evaluate the usability of the environment. Especially for the response system, the learners answered that they found it appropriate, motivating and interesting to take surveys during class using our environment. In a 1-5 scale the results about the students' confidence using the system shows an average value of 3.68 and standard deviation of 1.15.

4. Conclusions

From the experimentation part of this research, we learned that the application of ubiquitous computing in classroom settings could reward numerous benefits to the teaching/learning process, as long as it does not become an obstacle for its natural flow. According to the results of the questionnaire, the students think that the environment is easy to use and provides a fine opportunity to interact with the professor and among classmates as well, in an informal way, but with certain structure and order. It was of our particular attention the way the students felt more interested in the lecture contents while answering short tests through the response system. By simply answering short tests through the web application interface, they felt more active and important in the classroom where normally they play the extremely passive role of information receptor. Seeing the graph results for each question, help them in the reflective process to understand their position inside the class. The anonymous conditions encourage them to answer free of any social inhibitions or prejudices. Nevertheless, some students felt uncomfortable with the text input interface of the Pocket PC PDA; especially those who didn't had any previous experience with the usage of these devices. We believe that in the coming years, the human interfaces of new mobile devices will allow easier, better and richer interaction.

Traditional learning management systems (LMS) usually don't integrate tools that support real-time activities such as response taking or data gathering from the learners. The BSUL project aims to integrate these functionalities with the ones provided by other LMS, and become a sustainable test bed for evaluating the impact and opportunities of mobile digital technology in classroom settings, from both pedagogical and technological perspectives.

We have evaluated the performance of the environment with successful results, however, is still needed to conduct further usability evaluations and examine the system not only from the students perspective but also taking into consideration the teacher's, and with this in mind try to include different learning patterns, to evaluate other modules.

References

[1] Ayala, G. & Saito, N. (2003) Using the JSP model 2 architecture for implementing agents for a lifelong learning environment. Proceedings of the EDMEDIA 2003, (1), 436-443. Honolulu, HA, June 2003

[2] Ayala, G., Paredes, R. (2003) Learner model servers: personalization of web based educational applications based on digital collections. Proceedings of the EDMEDIA 2003, (1), 432-435. Honolulu, HA, June 2003.

[3] Crawford, V. & Vahey, P. (2002) Innovating the user of handheld technology in K-12 teaching and learning: Results from the Palm education pioneers program. American Educational Research Association Annual Conference. New Orleans, LA, April 1-5, 2002.

[4] Gay, G., Stefanone, M., Grace-Martin, M. & Hembrooke, H. (2001). The effects of wireless computing in collaborative learning environments. International Journal of Human-Computer Interaction, 13, (2), 257-276.

[5] Hoppe, H.U., Joiner, R., Milrad, M. & Sharples, M. (2003) Guest editorial: Wireless and mobile technologies in education. Journal of Computer Assisted Learning, 19, (3), 255-259.

[6] Liu, T.C., Wang, H.Y., Liang, J.K., Chan, T.W., Ko, H.W. & Yang, J.C. (2003) Wireless and mobile technologies to enhance teaching and learning. Journal of Computer Assisted Learning, 19, (3), 371-382.

[7] Ogata, H., & Yano, Y. (2004) Knowledge awareness map for computer – supported ubiquitous language – learning. IEEE WMTE2004, 19-26. Taiwan, March 2004.

[8] Pinkwart, N. et al. (2003) Educational scenarios for cooperative use of Personal Digital Assistants. Journal of Computer Assisted Learning, 19, (3), 383 -391.

[9] Roschelle, J. (2003) Keynote paper: Unlocking the learning value of wireless mobile devices Journal of Computer Assisted Learning 19, (3), 260 – 272.

[10] Sampson, D., Karagiannidis, C., Schenone, A. & Cardinali, F. (2002) Knowledge-on-demand in e-learning and e-working settings. Educational Technology & Society Journal, Special Issue on Integrating Technology into Learning and Working, 5, (2), April 2002.

[11] Sharples, M. & Beale, R. (2003) A Technical Review of Mobile Computational Devices. Journal of Computer Assisted Learning, 19, (3), 392 – 395.

[12] Want, R., Fishkin, K.P., Gujar, A. & Harrison, B.L. (1999) Bridging physical and virtual worlds with electronic tags. Proceedings of the SIGCHI conference on Human factors in computing systems, 370-377. ACM Press. Pittsburgh, PA, May 1999.

[13] Yau, S.S., Gupta, S.K.S., Karim, F., Ahamed, S.I., Wang, Y. & Wang, B. (2003) Smart classroom: Enhancing collaborative learning using pervasive computing technology. Proceedings of the 6th WFEO World Congress on Engineering Education & 2nd ASEE International Colloquium on Engineering Education. Nashville, TN, June 2003.