Supporting Classroom Activities with the BSUL Environment

Nobuji A. Saito, Hiroaki Ogata, Rosa G. Paredes J. and Yoneo Yano
Dept. of Information Science and Intelligent Systems, University of Tokushima
{nobuji,ogata, rosa, yano}@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 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, has enabled the transmission of digital multimedia between mobile devices through broad bandwidth wireless networks [13]. This technological advances have opened a new branch of research and development in the computer supported learning area, resulting in mobile learning tools using next-generation devices [8, 5, 11] 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. [7, 10, 3].

Computer Supported Ubiquitous Learning (CSUL) is defined as supporting the teaching/learning process using embedded and invisible computers in everyday life [8]. 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 [12]. 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, 15].

Generally 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 users 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 that supports his/her learning process, 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 (materials, exercises, 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 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: The activities in classrooms include some frequent tedious and redundant tasks. For instance, teachers take students' attendance, give students exercises and test sheets and after students finish their work he/she collects them, 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. In our proposed classroom, the teacher can take students' attendance using RFID tags in no time at all, and broadcast ready-prepared materials to every student's PDA. These designs enable numerous tedious tasks to be taken care of automatically at once, thus allowing teachers and students to have more time to focus on the important teaching/learning activities at hand.

Augmenting interaction: In traditional classrooms there is 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, thus 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, polls during class, and the students can 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. ClassTalk is a commercial product of Better Education Inc. that provides a similar approach. However we have integrated this function on our environment to augment the general functionalities.

*Recording teaching and learning processes as portfolios: L*earning material, quizzes and tests created by , 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: In 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 the 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.

For this research we developed a set of software components in order to give ubiquitous computing support for some classroom activities, including attendance taking, material distribution, response taking, report and short assignments (tasks) submission, group creation and student feedback. During class the students use a network enabled Pocket PC device, which connects to a central server application; and in the other hand the teacher interacts through a portable laptop computer or Tablet PC. We set up a classroom with 4 wireless network access points, a 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. 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 develop 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.

The main components of our proposed environment are: course and materials management, response, feedback and attendance taking (Fig. 2). We integrated personalization and learner modeling to our environment using a generic user model server [2]. Both teacher and students need to login into the system using their personal user name and password. New students can be registered from the environment main page. In the following subsections of this paper we describe the features of each one of the modules of the environment.

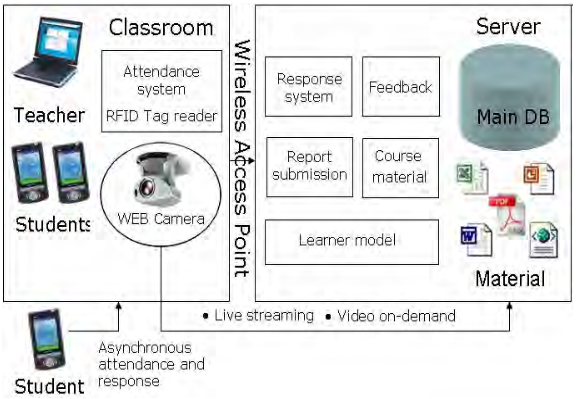

Fig. 2. Environment architecture.

2.2 Course 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. These materials can be any digital version of documents, books, presentations, etc. in any format available (video, sound, images or text). In order to enrich the course materials we have configured a web camera inside the classroom, making possible to view the class contents from outside using synchronous streaming video and the contents of the class are also digitally stored, becoming part of the course materials, for further posterior asynchronous reviews. The streaming video contents have a small delay of 10 seconds and are accessible during class time from the environment main menu. Every lecture is recorded in the main server, and can be viewed later on demand from a desktop computer or any other Internet enabled device.

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. We have created a desktop version and a mobile version for the students interface, thus making possible for the students to submit simple reports even during class In further work, we would like to create tools for report authoring for the students. Aside from usual reports, we have created an specific module for allowing collective data gathering from the students. The usage is described as follows: First the teacher assigns a group task that urge the students to obtain recordings, pictures or texts about the task. Using their PDA the students can review the requirements of each task and upload into the server the collected files. Later on this paper we will describe in detail one practical use of this feature of our environment.

2.4 Attendance Taking

The attendance list system is a support module, based on the RFID technology (Radio frequency identification). RFID refers to the technology that uses devices embedded to objects or places that are enabled to transmit data to an from RFID receiver. There are many kind of this devices that range in size from large pieces of hardware to very small devices the size of package labels. The main advantages of RFID over other existent technologies is the fact that RFID tags can contain more information and can be modified on the run. Furthermore, RFID reading does not require line-of-sight data transfer and according to some practical evaluations is very effective in harsh environments [14].

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 status 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.

Currently we are analyzing the usability and performance of this module, because in early evaluations we did not obtain the desired results due to technical issues regarding our RFID reader capabilities. However, since many successful applications have been developed using RFID components into different fields [14], we will still embrace this technology for further research.

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 the assessment on-demand [5, 8]. 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. Under some circumstances, the students can use their mobile devices outside the classroom; they should be able to review the class materials, submit their reports, and send questions to the teacher or other students.

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 even 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. Alone by itself, it may sound an uninteresting application of mobile devices into educational scenarios, but it has obtained many good results in practice, improving the students' participation in class [11, 7]. In our proposed work, the teacher uses a given application to create a set of questions represented in XML format. These questions can be displayed on any web browser, like the one on any Pocket PC device, through XSLT transformation templates. During class, the students answer the surveys using their mobile devices, and the system creates statistics with the students' answers. These statistics can be reviewed later, to support the teacher's awareness about the students' performance and understanding (Fig. 3). The teacher can assign a correct answer to each question in every survey, making possible to grade instantly the results of each student. If after the survey 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 interests. Capabilities and interest are stored in every student's learner model that will be described in the following subsection.

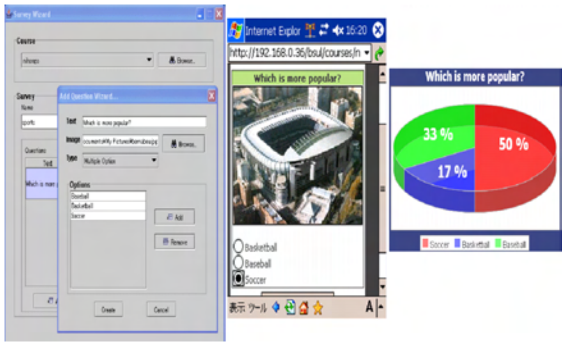

Fig. 3. Response System.

2.7 Learner Model

The learner model allows the personalization of the environment and allows to keep 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 purposes [6, 2]. This is an external component with a multi-model approach. A multi-module modular approach 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):

- Application model: The information about the application that requires the user modeling service. In the case of BSUL, such as constants, user stereotypes, and update triggers.
- User model: Contains the personal information of the user (name, email, age, gender, etc.), the user stereotype, the user

capabilities and interests, represented as a set of beliefs that the system has about a specific user through probabilistic values assigned to those beliefs.

- Usage model: Represents the user interaction history, contains his/her access logs and action logs. Could be used to determine the learner's behavior over a period of time.

- Environment model: Comprises data about the situational context in which the user is engaged. This informations includes hardware, software and location information of the learner.

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 ti 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.

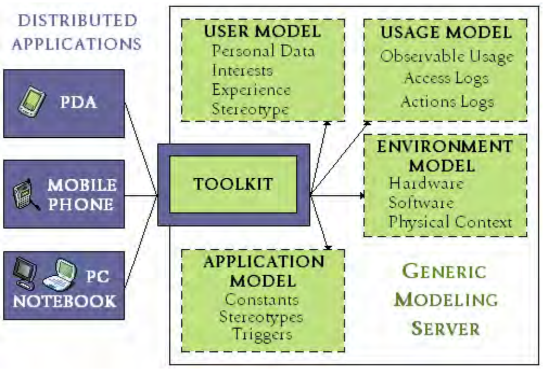

Fig. 4. Generic Modeling server

3. Practical use

3.1 Case 1: Classroom

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 very important in order to evaluate their performance, 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 his/her 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 specially 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.

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 (Fig. 5). Both the students in the classroom and the remote attendees had to answer to some small tests created using the response system.

Fig. 5. Students inside and outside the classroom.

Concerning the performance of the system, we obtained satisfying results with around 40 users concurrently, downloading material, visualizing the contents, answering the surveys, etc. 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. Specially 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 and comfortability using the system show a average value of 3.68 and standard deviation of 1.15.

3.2 Case 2: Interactive Event

In the CSCL 2005 international conference held in Taiwan from May 30^{th} to June 5th, we had the opportunity to present an interactive event that included a small demonstration of the usage of some of the functionalities of the BSUL environment (Fig. 6). The event had 15 participants from different nationalities such as Malaysia, Taiwan, USA, Japan, France among others, and academic backgrounds varying from Psychology, Education, and Computer Science. We set up several Pocket PC devices connected to a wireless Internet access point, and handed out one to each of our participants. The knowledge domain of our experiment was related to language learning, specifically to the acquisition of new vocabularies from foreign languages and the comparison between these and our own mother tongue.

Fig. 6. CSCL 2005 Interactive Event.

After explaining the means of interaction with the environment, we create a small test and asked the audience to answer to it. The aim of this test was to discover the participants' individual ability level in several languages. Because of the limitations of time and space, we obtained everybody's interests from direct input from the list of CSCL 2005 research topics. In normal conditions, the learners interests are obtained from their interaction with the system along the time, considering the learning resources they review online.

Three learning groups were created according to the students interests and capabilities obtained previously as mentioned. The criteria used to configure the groups was to get a balanced sum of capabilities while maximizing the number of shared interests among the members in each group. The teacher has the responsibility to weigh the importance of having groups with heterogeneous capabilities and how complementary skills or knowledge can maximize the benefits of the group members when working together.

Afterwards the presenter explained the 5 assigned tasks and engaged the groups in a competition for the realization of the tasks. Up to ten minutes were given for the realization of each task All the tasks required the students to discuss among their group and cooperatively gather voice recordings that meet the requirements for the given tasks using their PDA. For instance, in one task each group had to decide which is the most important and/or indispensable phrase to learn before going to a foreign country, and record that phrase in as many as possible languages that are spoken inside the group. Due to the even distribution of the participants capabilities among the groups, each group uploaded around the same number of recordings. One of the group uploaded recordings for “Thank you” in as much as 7 different languages including English, Chinese, Taiwanese, Spanish, Japanese, French and German. Other tasks (Fig. 7) engaged the participants in the collaborative gathering of voice recordings outside their own group, and in some cases outside the event room.

From the experience of the interactive event, we received interesting and invaluable feedback from our kind participants regarding the functionalities and other possible applications of the BSUL environment under different situations and/or scenarios, and from these ideas and suggestions we would like to revise our previous models and configurations in order to redefine some of the current functionalities.

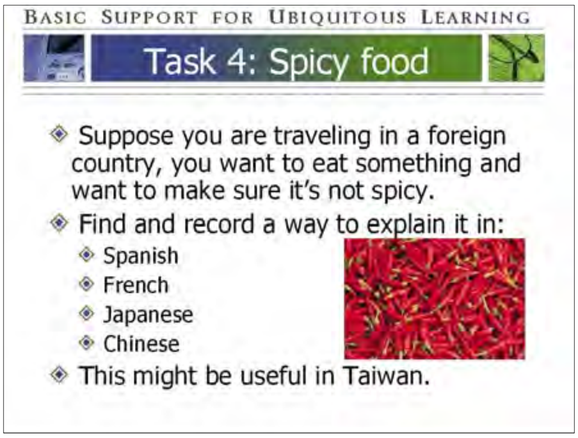

Fig. 7. Interactive Event task explanation.

4. Conclusion and Future work

In this paper we present the design and implementation issues of the BSUL environment for supporting classroom activities with ubiquitous computing devices. We included our first empirical evaluations on the performance and usability, based upon observation and a user questionnaire.

From the experimentation part of this research, we learned that the application of ubiquitous computing in classroom settings can reward numerous benefits to the teaching/learning process, as long as it does not become an obstacle for it's 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 a 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 a 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, specially 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 testbed for evaluating the impact and opportunities of mobile digital technology in classroom settings., from both pedagogical and technological perspectives.

For the improvement of our proposed components, we are analyzing and reviewing our original models. For example, in order to augment the usefulness of the attendance taking system, we will include the feature of automatic material download at the moment when a student takes attendance. In order to use the feedback system during field activities outside the classroom, we are analyzing the possibilities of including PHS connectivity, in our mobile devices. In our research group we have successfully implemented a system that makes use of Pocket PC devices with PHS connectivity to support field activities for language learning in real contexts. Another approach would be that since the use of cell phones with e-mail capabilities is widely used here in Japan, we could use this for sending attached images, recorded voice and video and configure a proxy component that receives the attachment and uploads it into the environment repository. Future improvements to our response system will include the possibility to cr

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.

Acknowledgments

This research work was partly supported by the Grant-in-Aid for Scientific Research No.15700516 from the Ministry of Education, Science, Sports, and Culture in Japan, and Hewlett Packard's Grant for mobile technologies in Education.

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]Kobsa, A. (2001a) Generic user modeling systems. *User Modeling and User – Adapted Interaction, 11*, (1-2), 49-63. Kluwer Academic Publishers, Netherlands.
[7] 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.
[8] Ogata, H., & Yano, Y. (2004) Knowledge awareness map for computer – supported ubiquitous language – learning. *IEEE WMTE2004*, 19-26. Taiwan, March 2004.
[9] Oppermann, R. (1996) Supporting continuous learning. *Proceedings of the Eighth European Conference on Cognitive Ergonomics*, 163-166. Eds. Thomas Green/José Cañas/Clive Warren. Granada, September 1996.
[10] Pinkwart, N. et al. (2003) Educational scenarios for cooperative use of Personal Digital Assistants. *Journal of Computer Assisted Learning, 19, (3),* 383 – 391.
[11] Roschelle, J. (2003) Keynote paper: Unlocking the learning value of wireless mobile devices *Journal of Computer Assisted Learning 19, (3),* 260 – 272.
[12] 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.
[13] Sharples, M. & Beale, R. (2003) A Technical Review of Mobile Computational Devices. *Journal of Computer Assisted Learning, 19, (3)*, 392 – 395.
[14] 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.
[15] 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.