Supporting Classroom Activities with the BSUL System

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ABSTRACT
This paper presents the integration of ubiquitous computing systems into classroom settings, in order to provide basic support for classrooms and field activities. We have developed 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 among each other and with the professor through an Internet-enabled personal digital assistant (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 including outdoor learning activities, and future research and development work.

Keywords
Ubiquitous learning, Mobile learning, PDA, GPS

Introduction
Generally, it is possible to say that in the upcoming years, it will become more and more common to see students bring mobile devices into the classroom. This means that mobile devices will be an embedded tool for supporting their learning process, in the same way a pencil, a ruler or a calculator does. Early evaluations suggest teachers and students respond to mobile devices favorably. For example, 90 percent of teachers in a study of 100 Palm-equipped classrooms reported that handhelds were effective instructional tools with the potential to affect student learning positively across curricular topics and instructional activities (Roschelle, 2003). Roschelle classified classroom applications in four categories:
1. Classroom response systems allow teachers to obtain responses from the students in a classroom. The system can recall the students’ answers and if applicable, create tables, histograms, or any other graphs (statistical studies, polls, etc.). This information then helps the teacher to be aware of each learner’s individual performance. The Educlick system, which consists of a set of wireless response devices and a response signal receiver, is a wireless response collecting system for promoting interaction between teachers and students, which increases students’ level of interest and holds their attention. In particular, students in Japan are very quiet and passive in the classroom. Therefore, response systems will be very helpful to increase students’ interactions.
2. Participatory simulations coordinate a group of learners to conduct simulations through the data exchange among students. The students are able to learn about many scientific phenomena by acting as agents of simulations in real phenomena. For example, the Virus Game was developed by the Massachusetts Institute of Technology (MIT) (Colella, Borovoy, & Resnick, 1998) to explain the process of how a virus is spread. Participatory simulation system for learning sort algorithm (PSSLSA) (Yin, Ogata, & Yano, 2006) also allows participatory simulation for learning sort algorithms where learners switch positions in ascending or descending sequence.
3. Collaborative data gathering systems help learners gain experience from real life, and deeply understand what they have learned. The learners touch and feel the actual objects, photograph them, and bring them back to the classroom (Kravcik, Kaibel, Specht, & Terregni, 2004). A very popular scenario is water-quality evaluation. Students take their Palms and probes to a stream, and each student takes measurements at different points. The students exchange their data by beaming, and they use handhelds to graph and analyze the combined data set
after going back to the classroom. Another example, the bird-watching assistance system (Chen, Kao, & Sheu, 2003), enables students to take photos of birds outside the classroom with handheld devices and to communicate with teachers and other students.

4. There are many other applications for mobile learning. For example, PiCoMap allows learners to make their own concept maps with mobile devices and exchange them by beaming them to one another. Language learning is also one of the important application domains of mobile learning. For example, the learning on the move (LOTM) system sends English vocabulary materials to Japanese students using a short message service (SMS) (Thornton & Houser, 2004). Also, PhotoStudy (Joseph, Binstead, & Suthers, 2005) supports vocabulary learning by sharing photos taken with camera built into mobile phones. Moreover, iTV (interactive television) has been used to support second-language learning (Pemberton, Fallahkhair, & Mastoff, 2005).

Those systems are, however, task and domain specific, mutually independent, and not integrated. Therefore, the systems do not provide seamless connections between activities.

This paper proposes basic support for ubiquitous learning (BSUL) environments as an extension of e-learning systems, which are general-purpose and domain-independent, and supports wireless and mobile learning across various domains and learning activities using mobile devices. Traditional learning management systems (LMSs) usually do not integrate tools that support real-time activities such as response taking or collaborative data gathering. The BSUL project aims to integrate these functionalities with the LMS, and become a sustainable test bed for evaluating the impact and opportunities of ubiquitous technologies in classroom settings. BSUL can also reduce time-consuming tasks in a classroom, facilitate interaction, and seamlessly connect indoor activities in a classroom setting and/or outdoor learning activities that are mentioned above. BSUL has a generic user modeling server to build, share, and reuse the learner model even if teachers use specific tools.

As for related works, Chan et al. argue that the use of wireless notebooks has the potential to change the learning environment (Chan, Hue, Chou, & Tzeng, 2001). A wireless technology-enhanced classroom (WiTEC) (Liu, 2007), which supports everyday activities in classroom contexts with Tablet PCs and wireless networks, has also been developed. The Educart system (Deng, Chang, Chang, & Chan, 2004) helps to bring tablet PCs into classrooms. The eClass (Abowd, 1999) captures and integrates automatically various information about a teacher’s lecture, including lecture notes, materials, voice, and images, in order to facilitate users’ access and review on the Internet after class. The European Networked Interactive Media In Schools (NIMES) project (Pinkwart, Hoppe, Milrad, & Perez, 2003) also provides the computer-integrated classroom, which supports in-class activities, with an interactive whiteboard and tablet PCs embedded in students’ desks in a networked environment. In addition, Classroom Presenter (Anderson, Anderson, Hoyer, & Wolfman, 2004) enables teachers and students to communicate with Tablet PCs in a classroom setting. In addition, Studio-1.00 project at MIT (Barak, Harward, & Lerman, 2007) aimed at enhancing active learning techniques, interactive programming, and the exploration of software development by the “in-class” use of mobile notebooks and electronic classrooms. These systems and computer-embedded environments have been reported to have a positive effect on students’ achievements in classroom settings. However, it is still necessary to investigate how to support ubiquitous learning [in both in-class and out-of-class] activities in one Student-to-one-computer-device settings (Chan, Roschelle, Hsi, Kinshuk, Shaples, Brown, et al., 2006).

We defined computer supported ubiquitous learning (CSUL) (Ogata & Yano, 2004a, 2004b) as supporting the teaching/learning process using embedded and invisible computers (Greenfield, 2006) in everyday life. This represents the intersection between the application of e-learning environments and mobile computing technologies, allowing effective anytime and anywhere learning experiences. CSUL enables 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 such as advice from teachers and/or experts on demand. CSUL implies new and different ways of interaction among learners, tutors, and materials (O’Hagan, 1999; Yang, 2006).

This paper describes the system development and functions of the BSUL environment and the next section illustrates two case studies in different domains such as mathematics and language learning. Finally, concluding remarks are provided.
The goal of this research is to design and develop a basic support for ubiquitous learning (BSUL) environment and to examine it in different classroom settings. In accordance with this, the design principles of BSUL are as follows:

- **Simple**: The software should be simple and work smoothly because handheld devices have a slow central processing unit (CPU) and a small memory compared to desktop computers.
- **Adaptive**: Since handheld devices are personal tools, the software should provide suitable information for the learner.
- **General purpose**: Handheld devices can be used for general purpose. Therefore, the software also supports various learning styles such as WebCT and FirstClass.
- **Collaborative**: Handheld devices have a communication function with other computers via WiFi and IrDA. Therefore, the software should support collaborative learning (Zurita, Nussbaum, & Salinas).

According to the design principles, BSUL has five characteristics and functionalities that aim to support the learning process inside and outside the classroom:

1. **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 teachers ask students to rewrite and/or demonstrate their completed assignment in front of the class on a whiteboard. Such procedures occur quite often in regular classrooms, consume much time, and interrupt the ongoing flow of the teaching activity. In our proposed classroom, the teacher can take students’ attendance using radio frequency identification (RFID) tags in no time at all, and broadcast ready-prepared materials to every student’s PDA. This enables 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.

2. **Augmenting interaction**: In traditional classrooms, there are a limited number of learning materials and, hence, students do not have enough information to allow them to relate the course content to 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. During class, teachers can assign quizzes, surveys, and polls for the students to answer using their PDAs, and in the event that students have a question, the teacher or teacher assistants can reply individually on the spot or after the class.

3. **Recording teaching and learning processes**: Learning material, quizzes, and tests created by the teachers, as well as the reports and assigned tasks submitted by the students, are recorded in individual or group archives. These records provide a nice repository to encourage and promote the teacher’s and students’ reflection, so that they can be aware of their overall performance. Students can also review learning materials and videos 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.

4. **Fostering collaborative learning**: During group activities, teachers have to face two important problems. First students’ interaction is based mostly on the exchange of ideas verbally, and this process cannot 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 difficulties related to the creation of effective learning groups. For instance, in any given group activity, the high-ability students in the 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 configure learning groups based upon the students’ interest and capabilities, allowing the teacher to create balanced groups where the members can get along based upon shared interests. The balanced group means each member has different capabilities and the same interests.

5. **Seamless interaction support between in-class and out-of-class activities**: Students can interact each other 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.

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. In class, the students use a network-enabled Pocket PC
device, which connects to a central server application. The teacher interacts through a portable laptop computer or Tablet PC.

We set up a classroom with three wireless-network access points (IEEE 802.11b standard), a controllable web camera to stream the video feed of the class content, a presentation screen and light projector, and a Pocket PC PDA for each student (Figure 1). Since the use of WiFi connectivity has a high battery-consumption rate, PDA cradles are conveniently located on the students’ desktop, for recharging the PDA 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.

Technical details

This environment was modeled after the standard specifications of the Java 2 Platform, Enterprise Edition (J2EE), implementing different software patterns, such as the model-view-controller (MVC). We chose this architecture because of the reusability of components and our previous experience developing web applications under this specification. In addition, this system has been used with numerous concurrent users, thus we needed a server framework able to support 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 (Figure 2). We integrated personalization and learner modeling in our environment using a generic user model server. 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’s main page.

Courses and material management

The main purpose of this module is to enable the teacher, assistants, and system administrators to help the 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 starts 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 it possible to view the class from the outside using synchronous streaming video. The content of the class is also
digitally stored, becoming part of the course materials, for further asynchronous reviews. The streaming video contents have a small delay of 10 seconds and are accessible during class time from the environment’s main menu.

![Figure 2: Environment architecture](image)

**Report submission**

Using the same web application, the teacher can assign reports for every course, giving the title, description, and deadline for each 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 online. We have created a desktop version and a mobile version for the students’ graphical interface, thus making it possible for the students to submit simple reports even during class.

Aside from usual reports, we have created a specific module for allowing collective data gathering from the students. The usage is described as follows: First the teacher assigns a group task that challenges the students to obtain recordings, pictures, or texts about the task. Using their PDAs the students can review the requirements of each task and upload the collected files to the server. Later on in this paper we will describe in detail one practical use of this feature of our environment.

**Attendance taking**

The attendance list system is a support module based on the RFID technology. RFID refers to the technology that uses devices embedded into objects or places that are enabled to transmit data to and from RFID receivers. There are many kinds of these devices that range in size from large pieces of hardware to very small devices the size of package labels. The main advantage of RFID over other existent technologies is the fact that RFID tags can contain more information and can be modified even at runtime. Furthermore, RFID reading does not require line-of-sight data transfer and, according to practical evaluations, RFID is very effective in dirty (not-so-clean) environments.

For the attendance-taking module, every student has a RFID tag. When the student enters the classroom, the system reads the RFID tag and sends a message to a web service based on the simple object access protocol (SOAP), asking to update the system database. We have proposed four different statuses for the students: attendance, absence, delay, and a fourth one called remote attendance, which means that the student is viewing 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’ leeway 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 website, but the students can view only 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 (Sharples & Beale, 2003; Hall & Bannon, 2006), we will still embrace this technology for further research.

Feedback system

The feedback system allows students to ask questions to the teacher at the moment they face something they do not understand during class or outside the classroom, supporting assessment on demand. The students can make a question in a liberal, anonymous way using the PDA. This is useful, because Japanese students are very shy and hesitate to ask questions. When the class is over, the students have to input 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 or she has understood the class. Only the teacher can see this value, which helps the teacher to monitor the students’ performance and evaluate his or 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.

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 collect 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, it may sound like an uninteresting application, but it has obtained many good results in practice, improving students’ participation and commitment in class (Sharples, 2000). In the BSUL environment, the teacher uses a given application to create a set of questions represented in Extensible Markup Language (XML) format. These questions can be open-answer or multiple-choice questions. A collection of questions is regarded as a survey that can be displayed on any web browser, like the one on any Pocket PC device, through XML Stylesheet Language Transformations (XSLT) transformation templates, making it possible to display the same survey in several formats, depending on the template used.

During class, the students respond to the surveys using their mobile devices, and the system creates statistics of their answers. These statistics also include information about the number of students who answered with the right option, and can be reviewed later to support the teacher’s awareness about the students’ performance and understanding (Figure 3). This system is mainly used during the course, and the teacher gives the answer. For multiple-choice surveys, it is possible to assign a correct answer to each question, making possible to instantly grade the results of each student. If a student wants to know the correct answer of any question that he or she answered incorrectly, the system can offer a list of some students who got it right in order to facilitate collaborative peer learning. The surveys can be created with two purposes in mind: to know the capabilities of the learner, and to find out his or 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.

**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. This paper proposes a generic user model server, which is an external component with a multi-model approach. This 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 the whole 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 (Figure 4):

1. **Application model**

   The application model is compounded by the particular modeling knowledge of the software applications domain such as a computer assisted language learning (CALL), and is divided into five sections: access information, constants, stereotypes, and triggers.
   - **Access information**: to verify and regulate the permissions granted to the applicants for registering themselves for the services of the system. Because the toolkit requires personal information for establishing communication, this system assures the consistency and privacy of the applicant’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 software can modify these values at anytime, to further regulate the behavior of its models. For example, if the administrator of the system gives the constant “8” for the users’ capabilities for making groups, the system makes a group where the sum of the members’ capabilities is greater than 8.
   - **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 who have previously interacted with the system. As the application software begins interacting with the new users, more accurate assumptions can be made, and their models will be gradually modified. For example, stereotypes can be defined as either beginner or expert in the application domain.
   - **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 a meeting, and the last 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. The following elements are regarded as relevant for this model:
   - **Personal information** to identify the user, such as name, email address, age, gender, nationality, address, etc.
   - **Information** about the user’s capacities and abilities, languages spoken, and educational background.
   - **User’s interests and intentions**, including 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. For the first item listed above, the information must be sent by the application, either complete or in part, through the toolkit interface. Several applications that contribute to the generation or maintenance of a group of models should be carefully modified, and their requests should be also 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. We have divided it into 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 the user usually access?
- Action logs. We consider three kinds of actions, selective (such as following a link on a web page, linking to a resource, or printing a file), confirmatory (bookmarking a page, saving or downloading a document), and disconfirmatory (deleting a file, removing a page from bookmarks). Other actions that fall into these categories may also be aggregated by the applications.

4. Environment model
The environment model comprises data about the situational context in which the user is engaged. According to Roschelle (2003), 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 three elements:
- Hardware information, such as processing speed, accessible input, and display devices. Basically, this 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 (Sharples, 2000).
- 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, 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 to a better insight of people and identify nearby objects with which the user can establish an interaction. 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. 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 remote method invocation (RMI) by applications programmed in Java.
- A web service endpoint that can be accessed through the SOAP protocol by applications developed using other programming.

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. In 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.

Case studies

Three experiments were conducted with BSUL as shown in table 1. The first one focused on the attendance taking, the response system, and the video streaming functions in an ordinary lecture-type classroom. In the second experiment, BSUL was combined with the map system in order to examine the possibilities for supporting activities outside classroom.

Table 1. Case studies for the evaluation

<table>
<thead>
<tr>
<th>Case study</th>
<th>Functions to be evaluated</th>
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<tbody>
<tr>
<td>1. Lecture</td>
<td>Attendance taking with RFID tags</td>
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<tr>
<td></td>
<td>Response system for increasing interaction</td>
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<tr>
<td></td>
<td>Video streaming and recording</td>
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<tr>
<td>2. One-day trip</td>
<td>BBS and map system</td>
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<td></td>
<td>Focus on the activities outside classrooms</td>
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Lectures

During the second semester of 2004 we evaluated the BSUL environment in a course at the University of Tokushima. The course contents were related to computer assisted instruction and the learners were all computer-science master’s 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 large number of students enrolled, attendance taking is a time-consuming task. Furthermore, in every class session, the teacher makes references to different materials, and all 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.

Figure 5. Students inside and outside the classroom
We divided the evaluation process into 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. During 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 and attend remotely. These students used the stream video source to watch and listen to the class contents and remotely download the materials (Figure 5). Both the students in the classroom and the remote attendees had to take some short tests created using the response system.

Concerning the performance of the system, we obtained satisfying results with approximately 40 concurrent users downloading material, visualizing the contents, and answering the surveys. However the students that remotely attended the class found it 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. The teacher commented out that the attendance-taking function worked well, and that the communication between inside and outside classroom was smooth.

At the end of the last session, we distributed 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. On a scale of 1 to 5, the results pertaining to the students’ confidence using the system shows an average value of 3.68 and standard deviation of 1.15 (see Figure 6). Also, the teacher found the response system helped to recognize the students’ comprehension, and felt that the classroom was more interactive than before.

Japanese language learning classroom

Language-learning outside the classroom with handhelds (LOCH) was conceived to help overseas students to learn Japanese while involved in real-life situations. Combining BSUL and map interfaces, the teacher assigns tasks to the students to go around town, interact with native speakers, and bring back their findings and/or questions. The background of this usage is:

Before using LOCH, overseas students sometimes got lost in the town and took much time finding their way back to the University. Therefore, it is necessary for teachers to understand where the students are.
It is very difficult for overseas students to tell others where they are, because there are only a few street signs in Japan and most of the street signs and the names of landmarks are written in Japanese only. Therefore, GPS is very useful to show the location of the student without any input.

Most foreign students have to take an intensive Japanese-language course for six months before entering the University. However, this instruction is not enough for the students to get by in daily life. In addition, there are a lot of dialects in Japanese. Therefore, these activities are very valuable and practical for overseas students to communicate daily with Japanese people in Tokushima. Teachers give overseas students the following tasks:

- **Interview a person.** Students go to an office and interview a person in Japanese for 10 minutes or so. The mission includes recording the interview and taking a picture of the person with the PDA. For example, a student may go to the dean’s office and interview the dean.
- **Gather information.** The mission entails going to a specific location and getting information. For example, a student may go to the bicycle-parking space at the station and ask the staff about the fee, business hours, the number of the parking lots, etc.
- **Buy something local.** For example, the student may go to the supermarket, buy “fish sausage” and ask how to cook it.
- **Have an experience.** For example, the mission may entail going to the University health center to have blood pressure taken.

By carrying out the above tasks, we expect overseas students to enhance their communication skills in Japanese, and to experience the local culture such as food, activities, etc. Students can make use of their PDAs for taking down annotations, recording questions, taking pictures, and reporting back to the teacher. At any time, the teacher monitors the position of the students and can communicate with them through BSUL’s BBS (bulletin board system), the map interface shown in Figure 8. The teacher guides the students through the task’s activities, giving suggestions or hints (such as “Ask somebody how to get there” or “You have to find the post office first”).

After all the students have concluded their tasks, they meet together at the classroom, which is equipped with a smart board and where the teacher has been following their progress. All the gathered information is displayed and discussed, and each student explains his or her strategies to the rest of the group. Similar situations are identified, and their solutions are shared under the guidance of the teacher.

Certainly, this approach provides foreign students with better insight into their daily life in Japan. There are myriad of expressions that students are unfamiliar with, and the purpose of the teacher is to give them the tools to respond and behave according to the situation. Furthermore, students are encouraged to go out in the community because the use of mobile devices seems new and interesting, and they have the assurance that the teacher can be immediately reached in case something goes wrong.
The prototype system was developed for PDA (Fujitsu Pocket LOOX v70) with Pocket PC 2003, second edition, which has a built-in 1.3 mega-pixel camera, SD, and CF card slots. Bluetooth GPS (Global Positioning System) and PHS (Personal Handy System) were attached (see figure 7). We chose to use PHS technology due to the availability of a one-year unlimited service program, which has a fixed cost regardless of the amount of time that the devices are connected to the Internet, or the size of the packages sent and received. This gives us enough time to experiment with the system several times. Likewise, the PHS has a faster connection speed (128 Kbps) and a much lower battery consumption than WiFi connections. Cellular phones were not used for this research, due to the fact that the resulting usage fees cannot be absorbed by the University, which means that the students would have to pay for their own expenses.

Two classes used with this system in two different semesters, with 13 users (3 women and 10 men, between 20 and 35 years of age). All of them were overseas students enrolled in the Japanese language intensive course at the University of Tokushima. The students (from Korea, Bangladesh, Bhutan, China, Egypt, Peru, Malaysia, the Philippines, and Thailand) had different levels of expertise in the use of computer devices. Besides the students, two teachers of this course were directly involved during the development and experimentation phases of the project.

Since the students were not familiar with the use of PDAs, we organized a hands-on session one week before the one-day trip, and distributed the devices and the usage manuals for the students to get acquainted with. Subsequently, the teachers scheduled the tasks for the students, which included such activities as: “Go to the tourist information stand in Tokushima Station and enquire about the places you can visit in just one day and the price. Record the answer of the stand attendant and send it back” (Figure 9 [A]), or “Go to the Awaodori Museum and enquire about the price and schedule of the rope way. Bring back the schedule and send the recording of the characteristic music of...
the Awaodori, continuously playing inside this building, and a picture of the souvenirs displayed in the shop” (Figure 10).

The day of the experimentation, the students gathered in the classroom with the teachers, picked up their PDAs, and received instructions for completing the first task. Subsequent tasks were provided by the teacher when students successfully achieved the expected results.

After the experimentation, the students answered a questionnaire, assigning a number between 1 and 5 to each one of six questions (where 1 was the lowest and 5 the highest score) and writing down the advantages and disadvantages of the system, as well as their personal comments about the experience. Average results of the questionnaire and the standard deviation for each set of answers are shown in Table 2.

Table 2. Results of the questionnaire

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Ave.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>Do you think that the one-day trip with PDA was exciting?</td>
<td>4.9</td>
</tr>
<tr>
<td>Q2</td>
<td>Do you think the time allowed for completing the tasks was enough?</td>
<td>3.2</td>
</tr>
<tr>
<td>Q3</td>
<td>Do you think the PDA was easy to use?</td>
<td>3.4</td>
</tr>
<tr>
<td>Q4</td>
<td>Was the PDA helpful when you found some troubles completing the tasks?</td>
<td>4.9</td>
</tr>
<tr>
<td>Q5</td>
<td>Do you think the system was interesting?</td>
<td>4.2</td>
</tr>
<tr>
<td>Q6</td>
<td>Would you like to use the system again?</td>
<td>5.0</td>
</tr>
</tbody>
</table>

According to the answers to Q1, Q5, and Q6, the students enjoyed the experience and would like to use the system again. Opinions were divided when asked about the time allowed to complete the tasks, as illustrated by Q2. Similarly, some students found the PDA and the system easier to use than others (Q3). This is partly related to their level of expertise using computational devices, and to the fact that the operating system was in Japanese. In addition, the students had to change the battery during the trip but they didn’t know how to change it. Therefore, more training for using PDAs will be needed. Finally, students found the PDA to be helpful when confronted with situations that raised doubts or questions to bring back to the classroom, or were uncertain about the goals of their task (Q4).

The teachers were interviewed and their response to the system was positive, although they had the following suggestions to improve this activity for the next time:

- It was not so easy to teach how to use this system because some of the students were not used to using PDAs. Therefore it is necessary to make the students ease into PDAs before this class.
- The teacher was very busy giving advice to all students. The system should support the teacher with an online help system.
Sometimes the Internet connection was disabled. Also we had to change the PDA’s battery. Further technological improvement is necessary.

Amid other comments, the teachers found the system to be useful for the students to practice Japanese in a real social context, and reported that the students’ confidence for speaking increased after the experiment.

Conclusion and Future work

Schools will still be around in the future, but education and teaching will be a combination between just-in-case learning in schools and just-in-time learning at anytime and anywhere. For example, we learnt English as a second language in junior high school just in case we have to communicate with an English speaker and so on. If you do not have an chance to use English, however, you will fail to remember what you learnt with time. Just-in-time learning works when you want to know how to say something in English because an English speaker is asking something in English. Therefore, we will need more research and development to strike a balance between ubiquitous learning and traditional learning.

From the experimentation part of this research, we learned that the application of ubiquitous computing in classroom settings and other activities could award 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 in an informal way, but with certain structure and order. Of particular note was the way the students felt more interested in the lecture content while completing short tests through the response system. By simply answering questions 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 graph results for each question helps students 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 PDAs, especially those who did not have any previous experience using these devices. We believe that in the coming years, the human interfaces of new mobile devices will allow easier, better, and richer interaction.

We have also evaluated the performance of the environment with successful results; however, it is still needed to conduct further usability evaluations and examine the system in different activities inside or outside classroom. Also we try to include different learning patterns in order to evaluate other modules. In the future work, we will apply some standard specifications such as IEEE learning object metadata (LOM) and IMS question and question and test interoperability (QTI) in order to facilitate interoperability and reuse.

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