# Handheld Review: Ubiquitous Technology-Based Method to Bridge Class and e-Learning

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**Abstract:** We propose "Handheld Review" as a ubiquitous technology-based method to bridge a class and e-Learning. The Handheld Review aims at motivating students to review previous classes and has the following characteristics: (1) in a short time just before the start of a class, materials for review are delivered to students (their PDAs) and (2) a material for review is personalized on the basis of each student's understanding status.

**Keywords:** Review, class (classroom), e-Learning, personalization, ubiquitous technology

## Introduction

In 1991, Weiser presented a vision for computers of the 21st century as follows: "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."[1] His vision is becoming a reality with ubiquitous technologies such as mobile computers, wireless network, IC tags, intelligent sensors, etc. Today's people are looking forward to early realization of ubiquitous society represented as "anyone can easily receive computer networked-based services anytime anyplace" or "anyone can unconsciously receive the right services at the right time at the right place."

Ubiquitous technologies are being applied to the field of learning (education) and the term of "ubiquitous learning" is likely to be acknowledged. If ubiquitous learning is broadly interpreted, there have been many kinds of ubiquitous learning systems. For example, mobile computers such as PDA (Personal Digital Assistant) and Tablet PC are used to gather field work data [2, 3] or see digital learning material [4] so that students can effectively know and observe natural objects. At a museum, the integrated technologies of RFID (Radio Frequency Identification), mobile computers, and embedded computers enable the visitors to receive digital contents interactively from the exhibits [5]. In classrooms, a classroom response system using handheld devices (including mobile phones) is a typical example to augment classroom activities (e.g., [6, 7]). To take other examples, a mobile computer is used to synchronize classroom activities with PC-based environment [8], to record classroom activities [9], or to share digital handouts and class information [10]. As shown in these examples, ubiquitous learning is expected as an innovative learning that can produce high learning efficacy. In addition, students would accept ubiquitous learning regardless of ubiquitous devices' defects (e.g., small size display and limited I/O interface) [11].

The remainder of this paper is organized as follows. Section 1 shows a problem in e-Learning practice, introducing e-Learning at the University of Tokushima. Section 2 highlights bridging a class and e-Learning as an approach to solving the problem. Section 3 describes the Handheld Review as a ubiquitous technology-based method to bridge a class and e-Learning. Section 4 outlines an experimental use of the prototype and concludes this paper.

## 1. Background

Today's university education is changing in consideration of diverse students. If students are not good enough in terms of basic scholastic ability, helping the students keep up with the level of university education is necessary. A promising measure against this issue is introduction of e-Learning. E-Learning is used generally for class replacement and/or class supplement (i.e., blended learning) and has earned satisfactory recognition as a learning method featured as "anytime-anywhere".

### *1.1 E-Learning at The University of Tokushima*

An e-Learning project was launched at the University of Tokushima and developed an original LMS (Learning Management System). The LMS has provided e-Learning services for about five years [12]. The e-Learning services are e-Learning material delivery (e.g., videos and digital handouts), assignment submission, messaging, on-line discussion, etc. In 2007, more than one hundred courses were registered in the LMS and the users (students and teachers) were cumulatively estimated at more than five thousand.

Our e-Learning model is a simple blended learning. In the model, (1) students attend a class and (2) after that they access the LMS and review the class from videos and/or handouts— the videos are recorded live at the classroom. Review using videos is effective in terms of reproduction (replay) of the class, because audio-visual interactions in the class (e.g., Q&A and discussion) are recorded to provide knowledge that handouts never provide.

With the stable provision of e-Learning services, the e-Learning project members undertook extension of the e-Learning services. For the extension, the members focused on ubiquitous technologies (devices), because most students willingly accept and handle new technologies. And, the members proposed ubiquitous learning (u-Learning) as ubiquitous technology-based extension of e-Learning services and developed some u-Learning prototype systems (e.g., [13, 14, 15]). In addition, about two hundred PDAs have been prepared for students and wireless LAN (Local Area Network) environment covering the campus widely has been developed.

### *1.2 Are Students Routinely Reviewing Previous Classes?*

We conducted an anonymous survey on tendency of university students' review. The mean value of the 5-degree question "Are you routinely reviewing previous classes? (1: Absolutely no, 5: Absolutely yes)" from 147 students was 2.53. This value may indicate that many students are attending a class without sufficiently understanding previous classes. In addition, the LMS access log data made us presume that students were doing a quick review only just before the regular test, although materials for review (e.g., videos and handouts) are always available in the LMS. This situation, which is undesired for teachers expecting that e-Learning is routinely used in order for students to review previous classes, should be improved quickly.

## 2. How to Motivate Students to Review Previous Classes

From the background, we focused on how to motivate students to review previous classes using e-Learning and started to design a ubiquitous technology-based e-Learning system called "Ubiquitous Classroom".

### *2.1 Low Connectivity between Classroom and e-Learning*

We think that low connectivity between a class and e-Learning does not motivate students to review previous classes using e-Learning. Our definition of the connectivity is "How closely e-Learning is involved in a class." This definition will seek the essential for blended learning. On a conceptual level, e-Learning can be closely involved in a class. On a practical level, however, e-Learning is often difficult to be closely involved in a class due to human factors. In other words, the connectivity often depends on a teacher's effort. If a teacher does not continue to consciously involve e-Learning in a class, students may gradually be forgetting the presence of e-Learning.

The goal of this study is that many students are routinely reviewing previous classes using e-Learning. This goal means successful blended learning. It is useful that LMS delivers materials for review to students, but it is not still enough in terms of the connectivity. Simply delivering materials for review—making the materials always available in the LMS— may not motivate students to review previous classes. Effectively delivering materials for review is necessary for successful blended learning.

Therefore, this study focuses on how to effectively distribute materials for review, that is, how to improve the connectivity using ubiquitous technology.

### *2.2 Principle of Improving Connectivity*

An important point for improving the connectivity is how to seamlessly bridge (connect) a class and e-Learning. To be more precise, the important point is how to reasonably lay out the situations where (1) students have to review previous classes routinely using e-Learning and (2) the students can review previous classes readily and effectively. Therefore, a ubiquitous technology-based method satisfying (1) and (2) must be considered.

## 3. Handheld Review as Bridge between Class and e-Learning

We propose "Handheld Review" as the above method, which works as the bridge between a class and e-Learning. To build the bridge, we use PDA and RFID as the interfaces for effective delivery of materials for review.

### *3.1 Overview*

Some teachers arrange time for review in a class to make the students review the previous class (e.g., by a quick test). The Handheld Review was inspired by this method.

The characteristics of the Handheld Review are (1) in a short time just before the start of a class, materials for review are delivered to students (their PDAs) and (2) a material for review material is personalized on the basis of each student's understanding status. The composition of the Handheld Review is shown as follows (Figure 1).

- *Students:* Every student has a PDA equipped with an RFID card scanner and also has a student RFID card containing his/her student ID.

- *Teacher:* Before a class, a teacher creates digital handouts, quick tests, materials for review, static personalization rules, and class data (e.g., teaching plan, classroom ID, topic list, and attendee list). And then the teacher uploads these to the LMS. The teacher brings his/her mobile computer to a classroom in order to send class control data (e.g., a command to deliver a quick test) to the LMS.
- *Classroom:* A classroom RFID card containing classroom ID is attached to the door of each classroom. Wireless LAN is available inside and outside the classroom.
- *LMS:* LMS performs student authentication (attendance check) and delivers a personalized material for review. For the personalization, the LMS collects each student's answers to the quick tests given in classes and then builds his/her student model from the collected answers.

The Handheld Review brings the following learning efficacies.

- A student is motivated to review previous classes, even if time for review is short.
- A student supplements his/her insufficient understanding of previous classes and becomes ready to understand the current class.
- A student gets aware of his/her current understanding status and is motivated to review previous classes using e-Learning more thoroughly after the class.

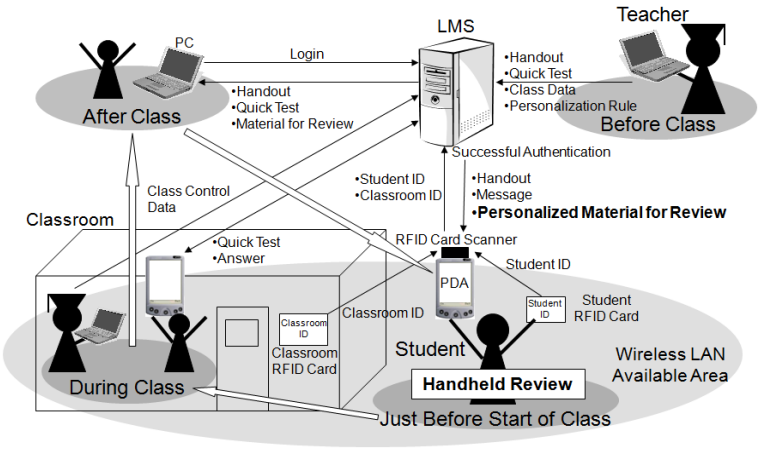


Figure 1: Composition of Handheld Review

## *3.2 Personalization of Material for Review*

The personalization mechanism in the Handheld Review is simple. The following subsections describe the personalization mechanism.

### *3.2.1 Personalization Strategy*

The Handheld Review requires students to complete review in a short time. Therefore, our personalization strategy is to reasonably downsize a material for review. To implement this personalization strategy, we divide a material for review into small units corresponding to each fine-grained topic taught in a class. The small unit is mainly embodied by a question included in a quick test. A material for review is downsized for each student through removing the small units that he/she has understood. In other words, a material for review is reconstructed from the small units corresponding to fine-grained topics that a student has not understood.

### *3.2.2 Class Model*

The class model hierarchically represents topics and a teaching plan (Figure 2). On the top layer, the class name (subject) is assigned. On the sub layer, broad topics (chapters in a textbook) that make up the class are assigned in the order of each time of the class. On the

sub-sub layer, fine-grained topics (sections in a textbook) that make up each broad topic are assigned. On the bottom layer, questions asking about each fine-grained topic are assigned, which make up a quick test corresponding to the fine-grained topic.

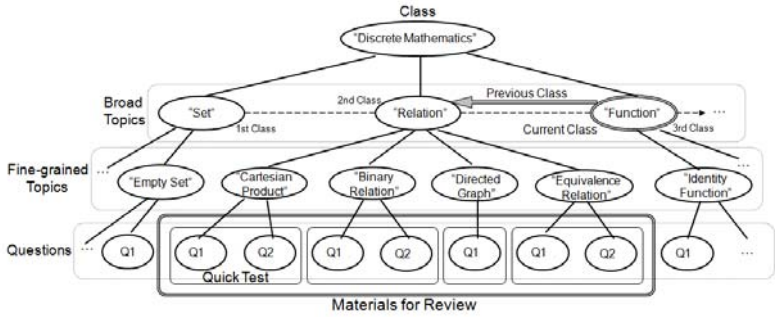


Figure 2: Class model

### *3.2.3 Student Model*

The student model represents each student's understanding status in a simple overlay model associated with the class model (Figure 3). Understanding status is judged from a student's answers to the quick tests as follows.

- If a student answers correctly all questions asking about a fine-grained topic, he/she is judged as the student who has understood the fine-grained topic.
- If a student answers incorrectly one or more questions asking about a fine-grained topic, he/she is judged as the student who has not understood the fine-grained topic.
- If a student has understood all fine-grained topics in a broad topic, he/she is judged as the student who has understood the broad topic.
- If a student is absent from a class (a broad topic), he/she is judged as the student who has not understood the broad topic.

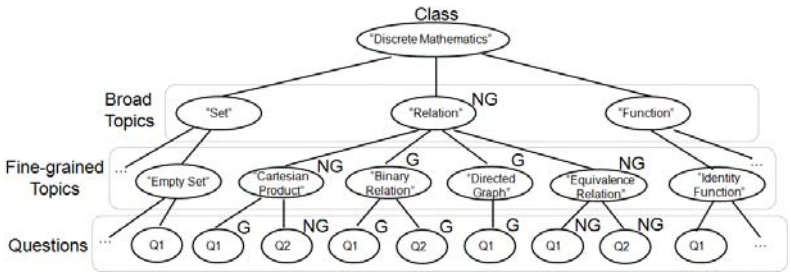


Figure 3: Student model

### *3.2.4 Personalization Rule*

The personalization rule is static for each class. Description of the personalization rule is simple based on our previous work [16]. The personalization rule consists of minimum required items for describing the rule (e.g., topic name, understanding status, type of material for review, and condition). The teacher accesses the LMS and describes the rule by selecting numerical values or property values for his/her each class. The personalization process according to a typical example of the rule is shown as follows.

RULE = {"Topic A", false, question, {last_answer, = =, incorrect}}

i. A student's understanding status of "Topic A" (a broad topic or a fine-grained topic) becomes the target being examined.
ii. If the understanding status is "false"— he/she is judged as the student who has not understood "Topic A", questions included in the quick test asking about "Topic A" are selected as the small unit candidates for reconstructing an appropriate material for review.
iii. From the small unit candidates, the questions that the student answered incorrectly last are picked up ({last_answer, = =, incorrect}).
iv. The questions picked up are delivered to the student as the personalized material for review.

### *3.3 Learning (Review) Process*

#### *3.3.1 Just Before Start of Class*

*(1) Student Authentication*

When entering a classroom, a student scans his/her student RFID card and the classroom RFID card using his/her PDA. The scanned ID data are sent to the LMS via wireless LAN and it is checked whether he/she is one of the students taking the class. This no-password student authentication using RFID, which frees students from remembering and entering ID and password, works as attendance check. Figure 4 shows a snapshot where a student is trying the authentication.

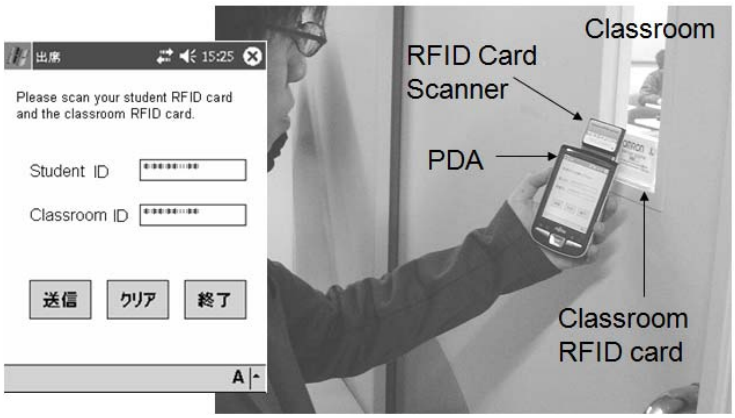


Figure 4: Snapshot of authentication using RFID

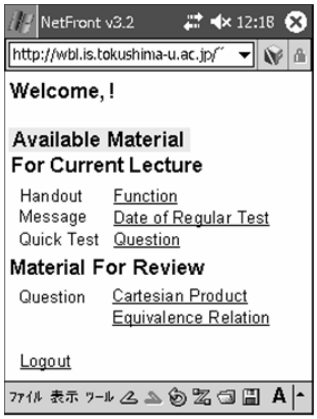


Figure 5: Personalized top page

*(2) Handheld Review (Short-time Review)*

Immediately after successful authentication, the student's top page is automatically presented. On the top page, handouts and messages prepared for the current class appear as hyperlinks. If the student's understanding status meets the personalization rule, the personalized material for review appears as an additional hyperlink(s). Figure 5 shows a student's top page including hyperlinks ("Cartesian Product" and "Equivalence Relation") of the personalized material. The student selects one of the hyperlinks and immediately the corresponding question is displayed. Figure 6 shows a question displayed as the personalized material and a snapshot where a student is trying to answer the question. Every time the student answers a question, the feedback to the answer (correct or incorrect) is displayed. The student is allowed to skip the review. Currently, a single-choice concise question is adopted in terms of usability so that students can complete review in a short time.

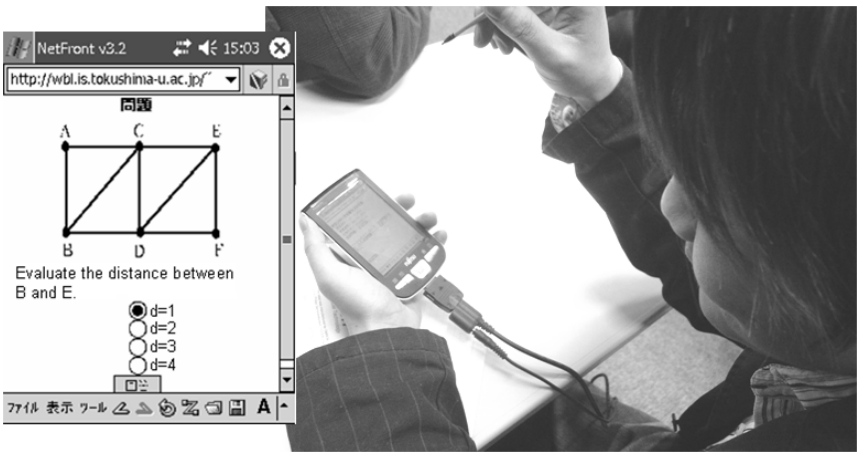


Figure 6: Snapshot of review just before the start of a class

*3.3.2 During Class: Quick Test*

A quick test is delivered simultaneously to students (their PDAs) in the class, if prepared by the teacher. The students answer every question included in the quick test. A student's answers are sent to the LMS and judged, and the result of the answers is displayed on his/her PDA or the classroom screen. The student gets aware of his/her current understanding status from the displayed result. The answers from each student are used to build his/her student model.

*3.3.3 After Class: Review*

Students who get aware of their current understanding status may be motivated to review previous classes using e-Learning more thoroughly after the class. As a matter of course, some students may review previous classes in a traditional style (e.g., reflection on notebooks).

*3.4 System Implementation*

The "Ubiquitous Classroom" prototype performing the Handheld Review has typical client-server architecture. The following part briefly describes the system implementation.

*3.4.1 Client Component*

The client components working on a PDA (Windows Mobile 2003) are an RFID scanning function and a Web browser. The RFID scanning function is implemented using Microsoft Visual Studio .NET C#. After the student authentication, the client component leaves the post-transaction to the browser.

*3.4.2 Server Component*

The server components working on a Linux server are implemented using PHP and MySQL. After the student authentication, a request from a student is transmitted to the server component and then the reply to the request is transmitted to the browser. Basically, these behaviors are not different from a typical web-based LMS.

## 4. Conclusion

This paper described "Handheld Review" as a ubiquitous technology-based method to bridge a class and e-Learning, which aims at motivating students to review previous classes.

We conducted an experimental use of the prototype in a small class (12 students) and had a questionnaire to examine whether the Handheld Review was accepted by students. The students used the prototype in seven times of a fifteen-class series to familiarize themselves with the prototype. The Handheld Review was activated only in the last class (of the seven times). Nine students answered "Yes" to the closed question "Did you review the last class using the material for review displayed on your PDA?" The other three could not receive the material due to bad reception of wireless network; hence, they answered "No". The mean value of the 5-degree question "Did the material for review help you to understand the today's class? (1: Absolutely no, 5: Absolutely yes)" from the nine students was 4.0. The mean value of the 5-degree question "Did you have enough time to review using the material just before the start of the today's class? (1: Absolutely no, 5: Absolutely yes)" was 3.4. Five of the nine students answered "Yes" to the closed question "Did the material for review motivate you to further review the previous classes after the today's class?" The five students answered that they were going to review using the handouts stored in the LMS and/or the textbook. From these results, we feel that the Handheld Review is

likely to be accepted by students. We have not yet verified the efficacy of the Handheld Review in detail. Especially, the following matters must be clarified from large-scale practical experiments: (1) whether the Handheld Review actually improves students' understanding statuses, (2) how much burden the Handheld Review imposes on teachers, and (3) whether the personalization including student modeling works properly.

In the small-scale experimental use, we encountered two technical problems: rapid PDA battery drain and unstable wireless network. Many batteries run out within about 60 minutes in 90 minutes class. To avoid these problematic situations, for example, we might need to mount battery chargers on classroom desks and install powerful wireless LAN access points in classrooms. These problematic situations indicate that redundant stable ICT infrastructure must be built up for practical (successful) use of the Handheld Review. This indication may be applicable to most ubiquitous learning.

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