An Application on 3G Mobile Phone and Two Dimension Barcode in Classroom Communication Support System

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Abstract: As a ubiquitous connection tool, we can see mobile phones being used widely and these days becoming particularly popular among adolescents. Currently in Japan, the invention of the two dimensional barcode or Quick Response (QR) code provides a convenient link for users to speedily enter web addresses into phones using the integrated mega pixel cameras. This paper focuses on the development of a classroom support system that combines mobile internet technology and QR code usage. The evaluation (which will be conducted in December, 2006 and May, 2007) will focus on how users make use of the QR code in the current system, which contains class attendance, class evaluation and student collaborative functions.

1. Introduction

1.1 Background

Mobile technology is a new frontier in telecommunication. The remarkable advantage of the technology is its ability to send and receive data quickly at any time and place. As a consequence, mobile devices take part in many applications, from common voice conversation to game entertainment or learning tool.

In particular, handheld technologies provide access to computing where student activities and learning occur. As a result of the rapid growth in the market, mobile telephone ownership and usage is now almost ubiquitous among student communities. Almost all young people today possess mobile phones. The increasingly powerful network and handsets are making mobile learning potential reality (Uden, L. 2007).

Mobile technology can make significant contributions in education. As learning has become more individualised and learner-centred, the new digital technologies in education should become increasingly personalised. Major advances in mobile-networked technology have enabled people to retrieve information and communicate regardless of their location (Sharples, 2000)

A research survey on learners' awareness of use of mobile phone in university classes (Sugawara & Muraki 2006) pointed out that around 60% of the targeted students would like to try a mobile phone based system in their class. According to the survey, the most frequently used application is mobile e-mail (which works in the same way as SMS in other countries). Apparently, on average, students are spending more than 1 hour per day using their mobile phone.

A study on a recently developed e-learning system for higher education (Yamamoto & Akahori 2006) indicated that m-learning in Japan is getting a lot of interest in the classrooms, as about 85% of the students accessed the class information website and mail every time or at least sometimes. This means that m-learning can increase students' interest and motivation. The system was based on use of e-mails and mobile phone accessible web pages. It was

followed up by a development study on the usage of QR codes and a mobile Java application for classroom communication (Chaisatien & Akahori 2006).

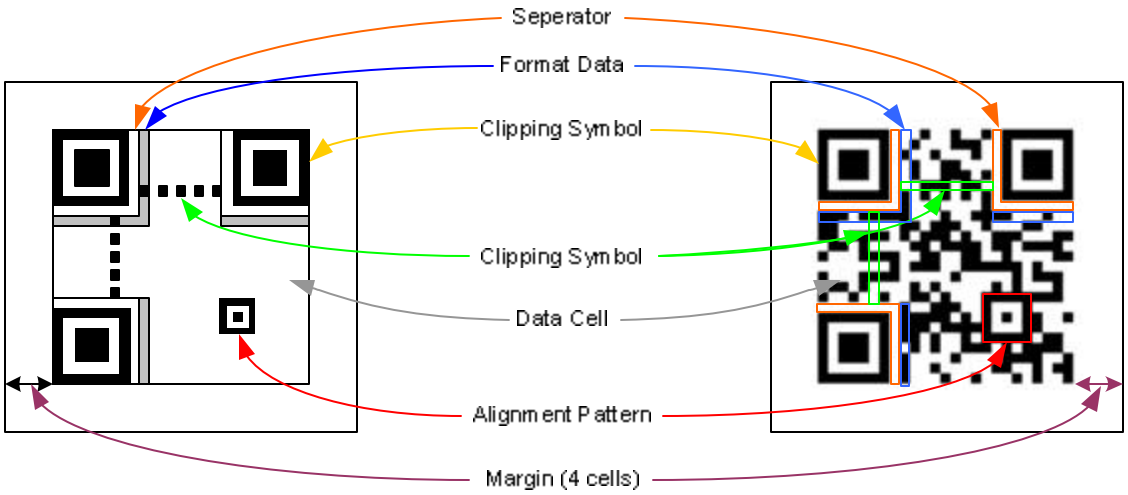

Figure 1: QR code model

1.2 Current report on mobile phone in Japan

According to a survey conducted at the end of March 2007, the number of mobile phone subscribers in Japan now exceeds 101.7 million (D2 Communications 2007). Over 65% of Japanese own an internet browser phone and nearly 100% of people among the 15 – 64 years old group age own a browser phone. Almost every hour of everyday Japanese people are using mobile phones to check emails, access web pages, play games and pursue hobbies.

In October 2004, about 75% percent of mobile phones in Japan are camera phones and it was expected that in 2005 the market penetration would saturate around 75%-85%, in other words almost all mobile phones in Japan would be camera phones. They also enable new services based on QR-code (2 dimensional barcode) input, which may lead to a variety of new transactions (Eurotechnology 2004).

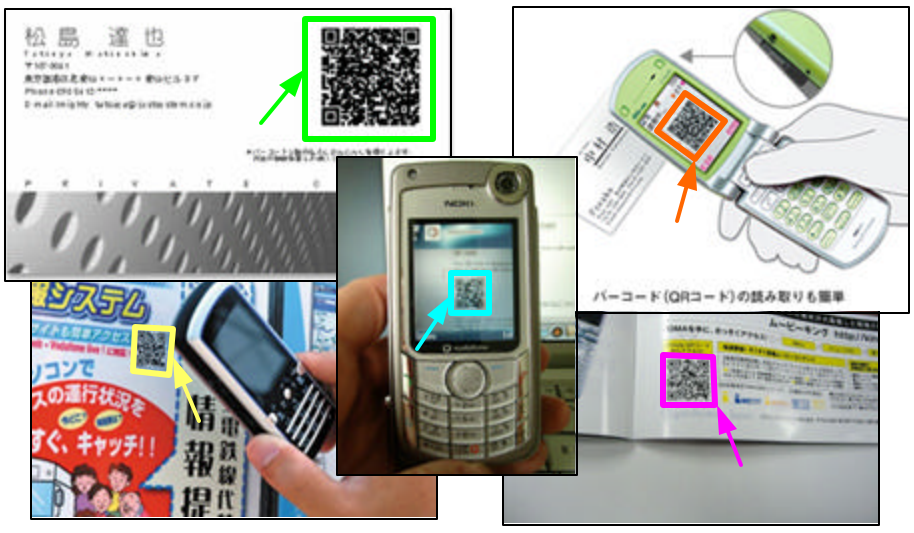

Figure 2: Current application on QR code

1.3 QR code

QR code (Fig. 1) is a kind of two-dimensional symbology developed by Denso wave incorporated (a division of Denso Corporation, Japan) which was released in 1994 with the primary aim of being a symbol that is easily interpreted by scanner equipment. QR code can be flexibly read in 360^{o} and stores up to 1,817 Japanese kanji characters using the QR code scanner (Denso Wave Inc. 2003).

Initially developed for logistics and car parts supply chain management by Denso Corporation, applications for QR codes have recently found explosive growth with the advent of camera phones. Most camera equipped mobile phones in Japan have the software already bundled into the phone, so users can easily work with QR code to read web addresses, or to encode their personal information on a name card or stamp (Fig. 2).

The most important advantage of QR codes is that instead of inputting long web address or large size information, the user can just take the QR code and easily use or store the data instantaneously. Thus QR codes help to overcome one of the most significant barriers to accessing mobile content. The QR code itself also has certain level of security as the code cannot easily be recognized without its own special reader. At present, QR codes are a very important information input and output tool, and are facilitating the growth of mobile usage (Eurotechnology 2006).

1.4 Service providers and mobile application

There are 3 main service providers in Japan (Tab. 1). In terms of market share NTT DoCoMo is the largest with more than half of all subscribers. The second largest is the KDDI au group which is more popular with students. The third largest is SoftBank Mobile (previously known as Vodafone Japan).

Mobile phone service providers freely provide development toolkits which allow anyone to develop applications for mobile phones. SoftBank and DoCoMo provide mobile Java development toolkits on their website. For KDDI au, programmers need to install a C++ compiler and install the BREW library available from KDDI au's website. Applications developed for DoCoMo phones can be uploaded to any website and can then be downloaded and installed by users. However, for SoftBank and KDDI au phones, applications can only be downloaded from the companies' own website. For these phones the application developer must register with the website in order to be able to distribute their application. In this respect DoCoMo is more open. As Y. Goto wrote, "it is very advantageous that the DoCoMo i-mode Java environment is open to a wide public; we educators can become a 'content provider' for mobile phone users" (Goto, Y. 2005). In addition, Softbank's web site require registration fee for the networking function in mobile phone application.

Carrier	Market Share	Mobile service name	Programming Language Capability
NTT DoCoMo	54% (52.6M)	i-mode	Java (Doja)
KDDI au	28% (27.3M)	EZ-web	C++ (BREW)
SoftBank Mobile	16% (15.9M)	Yahoo! keitai	Java (MIDP)

Table 1: Mobile service providers

2. Research objective and methodology

The learning support tool in this research is a mobile web browser and a mobile phone application using QR codes which will work on all 3 major mobile carriers' phones in Japan. Differ from the web base tool; the application base system will directly control the mobile phone's built-in QR code scanner and data networking using a Java application. The focus of this research is to build a complementary learning tool which delivers better communication and information access in large lecture. The developed system will help teachers with the students' attendance check and allow them to retrieve more information from students. Teachers will directly receive data from mobile questionnaires and indirectly from server data, for example system access timestamps. QR codes are used to reduce the long input required for any action in the student's mobile learning tools.

The main purpose of this study is to, first, on the developer side; demonstrate the possibility of implementing a mobile learning tool and the teacher support system. Second, on the user side; to gauge the student interest and attitude in this new media, to understand how to apply it in a dynamic classroom environment (which contains both lecture and group work) and to investigate the after school usage by the student. The study contains 2 phases. The first phase was a group work study which held during an intensive lecture course on 26 December 2006. The second phase, at the present time, is the on-going experiment in an undergraduate level class on "instructional design", for a full semester from April to July 2007.

The developed learning tools are targeting large lecture classes in which student have to attend the class and occasionally vote or submit their comment. The teacher will be helped by the web base administration tools to provide students with the class content and to check students' transactions. QR code will be used during the attendance check, class evaluation. The embedded QR code worksheets provided by teacher at each class will be distributed among students. In the group work study, a QR code pasted on each student poster in the student poster session can be scanned to send an evaluation for each group. The web-base learning tool will provide the same function as the application base does. Instead of taking QR code as a main operation, student access web pages and send information relatively to the ongoing class.

3. The mobile learning support tools

The mobile learning tools and class administration tools were developed mainly on the Java open source platform and JSP dynamic web page. The application base mobile client contains QR code functionality and HTTP networking which will be used in conjunction with QR embedded worksheets. Web base mobile client Teachers will use an administration server to provide any information regarding the lecture content, communicate with students via messaging service and query students' information. Fig. 3 shows the outline of this system.

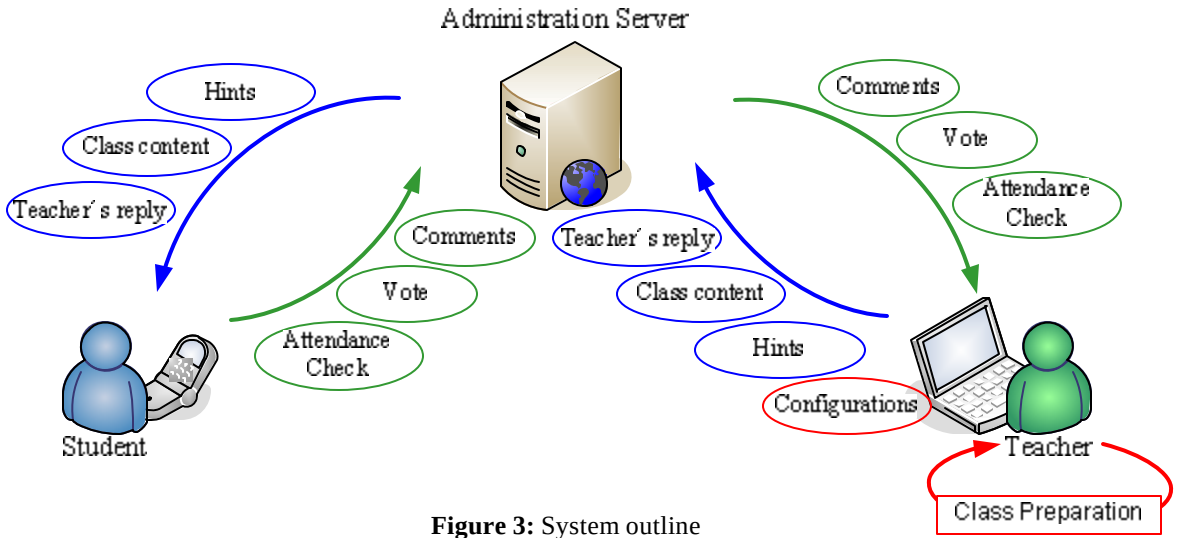

Figure 3: System outline

3.1 The mobile client

The mobile client will play a major role to facilitate students during the class and after class. The initial information needed to be registered is student personal information such as name, student ID and mobile phone e-mail address. Students who are using web base mobile learning tools have to input their username and password to logon into the system. Application base mobile learning tools will automatically transmit the phone's terminal ID with all the entered data which means username and password are not require. The terminal ID is a set of alphanumeric characters that provides unique identification for each mobile phone. The mobile client contains many functions which are described below.

3.1.1 Attendance check system

Application base mobile learning tools; at the beginning of a class, students will use their mobile phone to read the attendance QR code printed on the QR embedded worksheet. A message will be sent to the administration server to verify that they attended within appearance in the configured limited timeframe. Encoded class identification and security code contained in this QR code will be sent together with the phone's terminal ID. Web base mobile learning tools will require student to input attendance password. Note that attendance QR code and password will be changed according to class date.

The QR code can only be read correctly with the provided mobile learning support tool which means that students must be in the classroom before the end of the limited timeframe (20 minutes after class begun) to be able to register their attendance. Web-base learning support will require attendance password which will be announce during the class according to the same limited timeframe. Thus, all attendance in the course can be checked through the mobile learning support tool. This functionality is important because, in Japan, a high class attendance rate is essential to be able to receive the course credit.

3.1.2 In-class voting system

During the class, student can share their opinion by sending their vote. In this system, first, teacher will announce vote theme and choices for example YES, NO, NEUTRAL. Student will then submit their choice including short comment. All information sent to administration server will be then show up on projection screen via web browser. Figure 4 shows the class atmosphere when student use their mobile phone to vote.

Figure 4: Voting in class
Students sending information (left), Teacher giving comments on result (right)

3.1.3 Class evaluation system

During the class or before the class end, students will be asked to fill a short questionnaire-base evaluation using their mobile phone. Questions will be base on what did they feel about the class as well as how do they think about using mobile phone in class today. Teacher will review every evaluation after class together with text comment from student. Reply can be sent via mobile email personally or a short discussion before the beginning of the next class.

3.1.4 Hint and quiz summaries

This lecture class used paper quiz as a normal media for student to write their short note on while they discuss in pair or groups. Teacher will explain more detail and summarize those quizzes at nearly end of the class. At the end of the class, student can access hint and summaries using their mobile phone. This information cannot be access during a class and when the class ends, the hint QR code will automatically unlocked by the time configured in an administration server. At every time student accessing the hint QR code, the timestamp will be sent to the administration server for further analysis.

3.1.5 Information and messaging service

Subject matter in each lecture will be delivered to the mobile learning support tool. At the beginning of the course, the syllabus will be distributed to registered students. For each class, the teacher can plan the content and produce a short summary which can be announced via the administration server. In the same way, an announcement of any class cancellation can be made by this protocol.

The mobile learning support tool can also work as a messenger box. Students may submit their homework or any questions that they may have. The teacher can see these messages through the administrator server and correct homework answers and respond to submitted questions. Similarly, if student will be absent from a class they can notify the teacher by the same method.

3.1.6 Peripheral functions

All delivered and received information will be stored on the server but can still be accessed from the mobile phone. For instance, all evaluations that have been made, all questions submitted, all notes written or taken from the other source, including hints and the summary obtained from each lecture. The administration server will use only the terminal ID to determine linkage and relations in its database. This feature can cover the case where a student changes their mobile phone. By registering their new terminal ID, all data from the phone will be recovered.

3.2 QR embedded worksheet

Despite all the communication facilities provided, the mobile learning support tool itself can not provide main learning material. Therefore, the system will work together with a QR embedded worksheet provided by teacher at each lecture. This worksheet consists of 3 QR codes which are attendance, vote and evaluation QR codes. The quiz section was set beside those QR codes. The student will use the attendance QR code to verify their presence in the class. They can use the vote and evaluation QR code to provide feedback on the lecture.

In an earlier study on QR code usability on printed media (Chaisatien & Akahori 2006), the result implies that paper based QR code can be easily taken with a mobile phone's camera. The size of the QR code can even be printed smaller since it still can be read using the macro camera mode. In addition, QR code can also be printed in larger sizes such as A4 or even A3. The codes can then be displayed on the board at the front of the classroom. This would be useful in very big lecture classes where it is hard to hand out worksheets to every student.

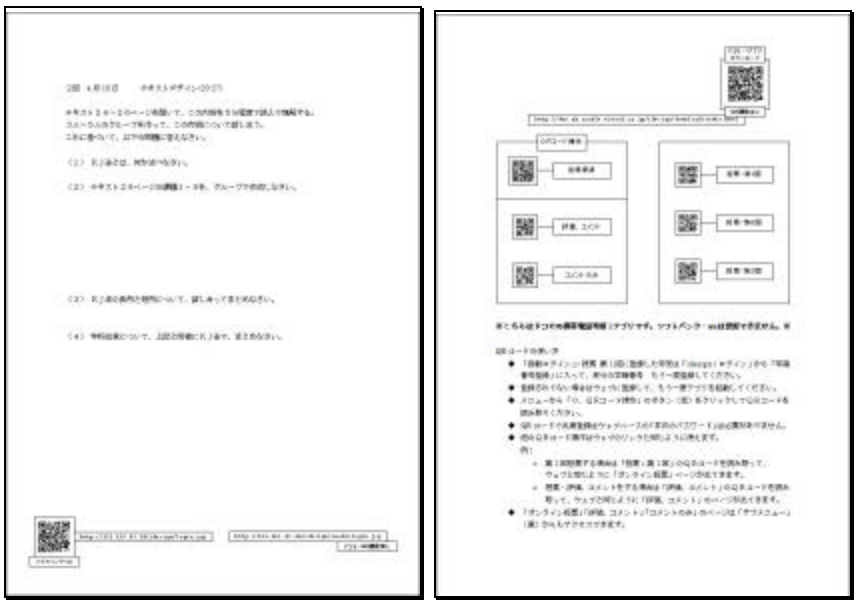

Figure 5: A sample of QR code embedded worksheet

3.3 Administration server

The administration server is basically working as an information center. The main functions are listed as follow:

1. Send stored messages to the mobile learning support tool such as a class information, class announcements, messages from the teacher, student attendance list and requested student's notes.
2. Receive and store any transactions from the mobile learning support tool such as student registration, student messages, student notes, lecture evaluation and timestamps when students access the hint QR code.
3. Perform time configuration and any wording to be used in the system e.g. attendance time limit, evaluation theme in each lecture and wording for each scale mark.
4. Provide a web page display of voting and evaluation information.
5. Form a database summary for further analysis.

The database on this server will contain the following data:

1. Students' personal information, terminal ID of each student's mobile phone and all attendance data.
2. Class schedule including selected evaluation themes that will be used for the lectures.
3. Class information and any special announcement e.g. class cancellation.
4. Voting and Evaluation data from student
5. Hint and Administration announcement
6. All student access log.

4. Usability test and evaluation

4.1 Phase 1: Group work session

In the group work session, we have test the evaluation component from the full version of the mobile learning support tool. During one poster session in a 3 day intensive course on "teacher training curriculum", 50 undergraduate and graduate students were grouped in 2s or 3s, and one of the students in the group was assigned as a group representative. Evaluation QR codes were pasted near each poster in the hall. Group representatives used their mobile phone to evaluate an overview of any poster they visit. The rest of the group will assess each poster by writing a comment on a paper provided. After the session finishes, the students were asked to answer a questionnaire to find out what they think about using this mobile tool. The overall feedback were used to revise the system.

4.2 Phase 2: Lecture session

In this session, we used the full version of the mobile learning support tool. Subjects in this session are undergraduate students in an "instructional design" course. All tasks, timing and person who will carry out the task are listed below

Task	Person	Time	Tool
Class preparation (sheets and QR codes)	Teacher / TA	Before the class	Administration server
Class registration	Student	Beginning of the course	Mobile phone
Class attendance check	Student	Beginning of the class	Mobile phone
Class evaluation	Student	During the class	Mobile phone
Quiz	Student	During the class	Paper
Review	Teacher	During the class	Admin server web page
Hint access	Student	After the class	Mobile phone

Enquiries	Student	At any time	Mobile phone
Reply student's questions	Teacher / TA	After the class	Administration server

Table 2: Procedures in each class

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5. Result

5.1 Phrase 1: Group work session

From pre-questionnaire in phrase 1, The service provider that student using was 24% for NTT DoCoMo, 28% for Softbank and 41% as a majority for KDDI au. We found that 53% of mobile phones in this class were capable of reading QR code. Most of the students usually use their mobile phone to send email and they are comfortably input text using numerical key pad. The amount of time they were using mobile phone is approximately 30 minutes per day. Moreover, 39% of these students used QR code, typically for accessing mobile website. Students also answered that QR code is very useful but may have some difficulties when they scan it.

After all, we found only 8 mobile phones that compatible with our system (DoCoMo phone with QR code reader). By insufficient number of subjects, the result from post-questionnaire will be shown mainly as qualitative aspect. [Score in box brackets indicates average and standard deviation calculated from usage rank out of 5]

5.1.1 From student's standpoint

(1) Group registration: In student's attitude about QR code in group register function, they think that it is a new tool which is convenient to use but they doubt that it may not be necessary to do so. [3.29, 1.38]
(2) Theme registration: It is convenient for them to check themes' duplication. The disadvantage is that the display is small and they cannot see all themes in one page [3.14, 1.06]
(3) QR code in poster session: The majority do not think that QR code is suitable to use in poster session since they have to get very close to the code in order to read them. And they comment that it would be useful in larger class. [2.71, 1.25] and QR code is easy to be scanned [3.71, 1.60]
(4) Software usability: Students think that this software is easy to use; colors help them easily understand what function they are using [3.86, 1.07]. They can operate the application without reading manual
(5) Handwriting vs. mobile phone: In poster session, students prefer voting paper since it is hard to input text using mobile phone [1.57, 0.53]
(6) Mobile phone application in classroom: Although handwriting is better and the usage of QR code is somewhat bothersome, students think that it would be convenient to collect much information in short time. [2.86, 1.57]

5.1.2 From teacher's standing point

(1) Using mobile phone in classroom: It would be easy for teacher to get large amount of data conveniently. A mobile phone usage in classroom can be seen as uncertain or misuse. We got low rating [2.71, 1.49] from using QR code in group register function because students did not clearly understand the point of using this (Please refer to the discussion section). For theme register function, we got only inessential comments [3.71, 0.95].
(2) QR code usage in poster session: It may take time for teachers to prepare the QR code [2.71, 0.95].

5.1.2 Statistical analysis from pre and post questionnaire

Finally, we analyze the same item used in pre and post questionnaire in
(1) Mobile phone as a convenient tool in university class: we received [2.71, 1.50] from pre questionnaire and [3.43, 0.98] from post questionnaire. ANOVA analysis shown that these 2 data sets are not statistically significant (p=0.31)
(2) Mobile phone software as a support tools in class room: from [2.86, 1.57] to [3, 1.29]. One student has stated that it was not necessary to use mobile phone software in classroom since it would be better to use web-base application. ANOVA analysis shown that these 2 data sets are also not statistically significant (p=0.85)

(3) Suggestion: Students suggested that we should build some input assistant function to help them type faster. Moreover, attendance registration function would be very useful in classroom.
(4) Other comments: one of the student comments about data packet communication charges.

5.2 Phrase 2: Lecture session

The result in this phrase still cannot be statically analyzed as we are still in the 4th week out of 15 weeks in this spring semester. In this class students are using DoCoMo 50.5% as a majority following by Softbank 47% and 7.5% from au KDDI. At approximately 90% of all student's mobile phones were capable of reading QR code. Over 50% of all students are using mobile phone more than 1 to 2 hour per day while 50% of students spend less than 1 hour accessing the internet from computer.

From pre-questionnaire in phrase 1, The service provider that student using was 24% for NTT DoCoMo, 28% for Softbank and 41% as a majority for KDDI au. We found that 53% of mobile phones in this class were capable of reading QR code. Most of the students usually use their mobile phone to send email and they are comfortably input text using numerical key pad. The amount of time they were using mobile phone is approximately 30 minutes per day. Moreover, 39% of these students used QR code, typically for accessing mobile website. Students also answered that QR code is very useful but may have some difficulties when they scan it. The most popular function in mobile phone is e-mail follow by order internet access, taking picture, talking on telephone and running mobile application. Students think that mobile internet access is convenient to use and they mentioned that they often access railway transit guidance page. 77% of students have tried using QR code, mostly for internet access.

After the first trial on mobile system in the class, most of the students stated that like that they can check all information they send via mobile phone, voting function is interesting and they doubt what is inside the hint page. Student gave nearly moderate score on system usability in the questionnaire.
About their opinion and motivation, they think that the use of mobile e-mail and internet to communicate amongst people is interesting and they do not resist about using mobile phone in classroom.

In the class, we used mobile system's function according to the content. Students comment that using mobile phone in the class is interesting especially voting function in both percentage and text format. And they feel that mobile phone can lower the distance between student and teacher in large lecture class setting as they can freely express their opinion using this system. Further analysis will be held after the semester end.

6. Discussion

6.1 Phrase 1: Group work session

Factors that might affect the experiment result in phrase 1 are
(1) Notebook computer were given to all groups in this session. Therefore, student might consider that web base application will be more useful in this class.
(2) Mobile phone application in this survey could not be used in every mobile phone as paper and other form of registration/voting are also being used for example we already grouped the student before they electronically register from their mobile phone by the fact that we have to spread out the DoCoMo phones holder to each group. Student might doubt the capability of the mobile learning support tools since it was presented as an additional task for them.

6.2 Phrase 2: Lecture session

(1) Student still worry about their attendance as it is the most accessed page.
(2) We got a lot of problem in the first and second day of the experiment, the operation time tend to become shorter in the later class.

7. Conclusion

We have developed a new opportunity to support a communication in a larger classroom environment. The application we have built in this study applies recent advances in mobile phone technology to m-leaming. We hope

that using QR codes in this system will allow us to achieve our goal of making an easy to use tool which will motivate student's interest. In this scenario, the teacher will be facilitated by the administration server. However, much information still has to be manually prepared. We plan to add more functions and revise some of the usability aspects of the system to make it more suitable for students and instructors.

The evaluation and revision is continuing at this moment. As this system mainly uses a server-client protocol, we are now studying the new possibilities in peer-to-peer communication. Thus, by enabling these features through widely used J2ME libraries, we can open more prospects in mobile learning worldwide than ever before.

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