Facilitating Classroom Questioning and Participation Through Smart Handheld Technologies

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1. Introduction

Using portable, handheld devices such as smartphones, PDAs and tablets is becoming a norm in our daily lives. Such a trend can not be ignored in the education setting, especially when numerous reports [1,2] indicate that the number of students who own an Internet-capable handheld device and use it very frequently to access the Internet is growing rapidly. Academic institutions and educators have realized not only that there is a need to bridge the gap between the way students live and the way they learn but also that the use of mobile devices on campus can actually enrich the learning experience [3]. As a result, during the past few years a wide variety of educational mobile systems and applications have been developed in order to engage more students, facilitate processes and overall provide better education. Many of these systems target specific teaching and learning issues and are supported by strong pedagogies. One such issue is the promotion of active learning during a class period. The current dominant handheld technology that can greatly enhance this particular aspect of learner engagement is a student response system or more commonly known as a clicker [4]. Clickers are handheld devices to enhance classroom participation by allowing all students to anonymously answer the instructor's questions. However, student engagement and classroom participation does not only involve answering questions but also asking questions, a situation that is not quite common in a classroom setting. There exist a number of reasons that discourage students from asking questions during a class. These negative pressures are primarily related to embarrassment and fear [5].

This paper presents an innovative educational application that runs on smart handheld devices and enables students to anonymously ask questions during a lecture. The paper discusses the pedagogical considerations and design decisions for both the student and lecturer components of this educational system which also enables an online library of real-time questions and answers. It then discusses the architecture and technologies that were used for the development of the mobile application. Finally, the paper concludes with an evaluation of the system and discussion for further enhancements.

2. Pedagogical Considerations

Education is not about a monolog from an instructor and the passive reception of information by learners; it is about a dialog between learner and instructor. As a result, students' questions during class are critical to learning since they create active engagement in the learning process [6]. While most instructors encourage and welcome questions, it is not quite common in a classroom setting [7]. One reason might be that such lectures aren't really designed for questions. The instructor has an agenda that has to be squeezed into a limited amount of time. Furthermore, as the number of students in a classroom increase, opportunities for interaction seem to decrease since it is practically infeasible for 100 students to each ask a question during a 50-minute lecture. Nonetheless, a number of psychological, social and cultural reasons [8,5,9,10,6] have also been identified as to why students hesitate to ask questions during a lecture. The most common ones are:

- fear of being labeled as incapable by the instructor
- stress they will not understand the instructor's explanation
- embarrassment in the eyes of their classmates
- anxiety of taking away time from important things the instructor has to say
- concern of wasting the time of their classmates
- fear that the question will be perceived as an insult to the instructor
- stress because of their accent (applies to learners who are not native speakers of the language of the country that the university resides)

Lastly, it is important to mention that class size compounds and amplifies the above feelings and reactions since the larger the class the less students participate [5]. In an attempt to abolish the aforementioned pressures and taking under consideration that smartphones and handheld devices in general are a way of life for students today, we created eWONDER. eWONDER is an educational system that aims to further promote active learning and student engagement during a lecture by allowing students to anonymously send questions to the instructor through a smart handheld device.

3. System Description

eWONDER is a sophisticated system that consists of a number of modules. Nevertheless, users directly interact with the following four:

- *Student application*: installed on a smart handheld device, this application allows students to anonymously type and send questions to the instructor during a lecture

- *Instructor application*: also installed on a smart handheld device, this application is used by instructors to browse the students' questions and optionally record audio of their answers

- *Notification application*: the specific part of eWONDER operates as a notifier and informs the instructor that a question has been received. This application can be used on any computer (desktop or laptop) that the a classroom is equipped for projections of presentations
- *Web application*: accessed through any browser, the web application enables instructors to setup a lecture session and students to browse students' questions and instructor's responses.

As it can be understood from the above, eWONDER supports three types of users: students, lecturers and finally an administrator. While there are a lot of parameters to the functionality offered by eWONDER, the high-level process of using the system can be described in the following steps:

1. An administrator creates an account for an instructor through the web application
2. An instructor can then login the web application and create an event. The term event implies anything that can have an audience like a lecture, a seminar or a tutorial. The initialization of an event generates a unique enrollment key. This key is announced to the audience (students).
3. When the event starts, a student in the audience who has already downloaded and installed eWONDER on a smart handheld device can enter the enrollment key in order to login into the event. For the duration of the event eWONDER then allows a student to type and send questions to the instructor. Students are not able to see questions posted by other students.
4. When a question is received, the instructor is notified through the notification application.
5. Incoming questions are clustered by keywords. This allows the instructor to determine the taught topics that students are experiencing problems but also to identify related or similar questions.
6. In order to view student questions the instructor also uses a smart handheld device. A question is then selected and answered in class. The answer that the instructor provides may be recorded. When this option is selected the text of the question along with the answer's audio file are stored and can be latter be accessed through eWONDER's web application. This enables the creation of a library of questions-and-answers.
7. The instructor may also choose to answer questions after an event has finished. These answers are also stored either in text or in audio format.

The figures below present three screenshots of the interface of eWONDER. Figure 1 displays the student login interface, figure 2 depicts the way a student can type and send a new question and finally figure 3 shows the instructor's view of received questions.

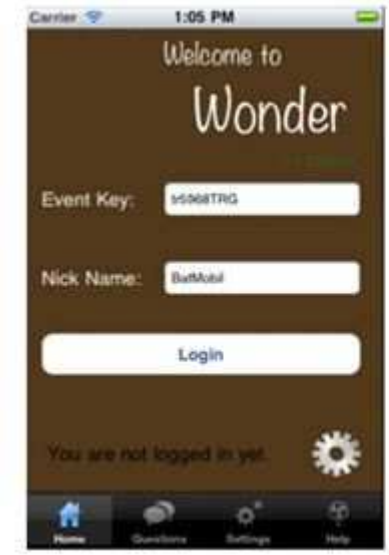

Fig 1. eWONDER login Fig 2. Enter new Question Fig 3. Received Questions

4. System Architecture and Technologies

The architecture of eWONDER is based on the client/server model and a network connection is required for the operation of the system. This however, does not impose any difficulties since current handheld devices are equipped with adapters for easy access to wireless networks which are freely offered by academic institutions. The high level architecture is presented in figure 4. Its six main components are: the lecturer application, the student application, the notification application, the web application, the web service, and finally the storage application. The first four components were discussed in section 3. The storage application is simply a database

that stores the information. The web service is actually the central system for achieving the communication between the various handheld devices.

Each of the components of eWONDER pertains at a certain logical layer in the overall design of the system. The presentation layer includes the components that present functionality and directly interact with users. It defines the user interface elements that are possible in each component and is application dependent. The logic layer defines the functionality and is also application dependent. It controls the whole application logic and all requests and responses need to pass through this layer. Finally, the storage layer is responsible for physical storage of all content and metadata.

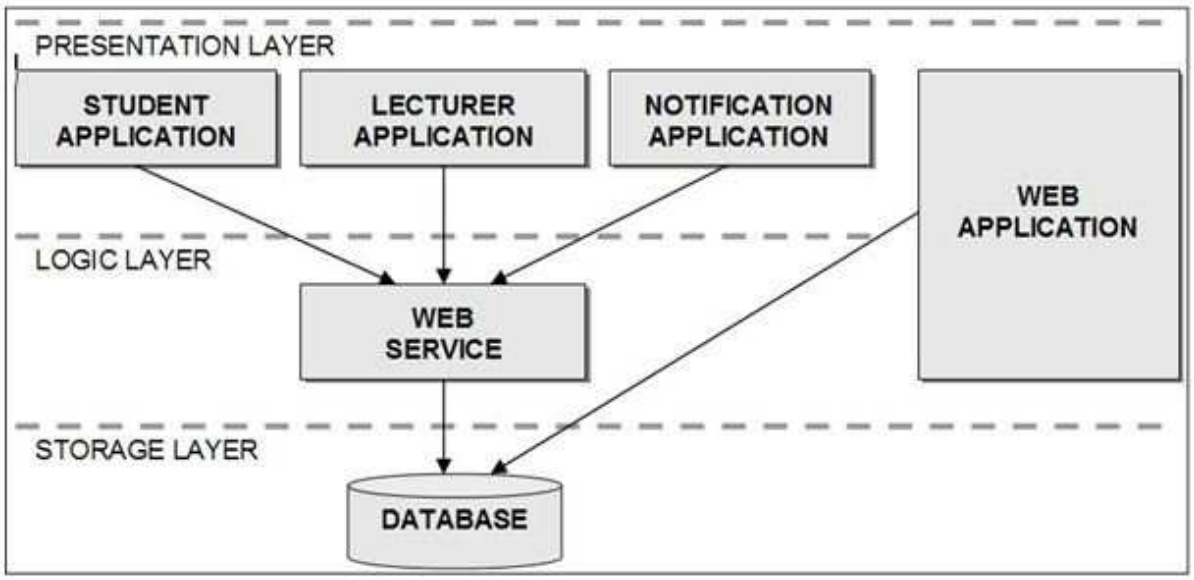

Fig. 4. eWONDER High Level Architecture

eWONDER was developed through a diverse set of technologies presented in table 1. It currently supports the Apple's iOS operating system and can be used on Apple's own devices such as their smartphones (iPhone family), tablets (iPad & iPad 2) and portable music players (iPod Touch).

Component	Technologies
Lecturer Application	Cooca Touch, Touch XML, Objective-C, UIKit Framework, MVC
Notification Application	C#, WPF, .NET Framework
Student Application	Cooca Touch, Touch XML, Objective-C, UIKit Framework, MVC
Web Applicaiton	C#, HTML5, Razor, JQuery, CSS3, MVC3, ADO.NET Entity Framework
Web Service	WCF, Restful, ADO.NET Entity Framework, .NET Framework, C#
Storage Application	MySQL

Table1. Technologies used for the development of eWONDER

5. Discussion and Heuristic Evaluation

eWONDER is currently in its first release. The complete functionality available to students is fully developed and thoroughly tested. The functionality offered to instructors is also completed and tested with the exception of the ability to audio record and store the answers to the students' questions. Finally, as discussed in section 3, questions clustering can be proven very useful for instructors in order to identify a specific area that students are experiencing difficulties. This functionality is currently unavailable. These two major characteristics of the system will be developed in the next release.

eWONDER needs to be evaluated in actual classroom settings in order to assess its educational value. However, before such a large scale evaluation is conducted, a validation study was required in order to identify possible usability issues, as well as, to determine major system errors. eWONDER was validated by performing the heuristic evaluation usability engineering method based on heuristics provided by Jakob Nielsen [11]. This method consists of small set of evaluators performing system tasks and checking compliance with a predefined set of usability principles (the heuristics). While Nielsen's heuristics [12] were initially developed to evaluate desktop applications, they still provide a useful foundation for evaluating mobile applications.

The evaluation was conducted by five evaluators who were selected based on their experience in software usability. More specifically, two of evaluators were experts in software usability and user interface design. They tested all the tasks offered to both lecturers and students. The remaining three evaluators were students with no knowledge of software ergonomics and conducted tests for the functionality offered only to students. Each evaluator performed the system tasks individually but met as a group at the end to aggregate the outcomes. The reported results revealed no system errors and minor usability problems which will be solved at the next version of eWONDER.

6. Conclusions and Future Work

The penetration and diffusion of smart handheld devices can not be argued. Such a trend can not be ignored in an education setting with young people who have grown up with such technologies. This paper presents the pedagogical concerns, the design approaches and the development of an educational mobile application which targets learners who experience any kind of difficulties and intricacies in asking questions during a lecture. The developed application attempts to facilitate active participation and promote learning by enabling learners to anonymously send text-based questions to the lecturer in real-time using a smart handheld device. The system can be used on Apple's devices like iPhone, iPad and iPod Touch and is currently in its first release. The heuristic evaluation which was conducted to validate the system yielded only minor usability issues. These will be handled in the next version of the system along with a couple of functionality enhancements. We plan to carry out a large scale evaluation study in an actual classroom setting to measure its effectiveness both in terms of pedagogy as well as acceptance level by the students. Upon satisfactory results of the latter evaluation, additional support for other mobile platforms (e.g. Android) will be provided, as well as, extensions for using the system not only from handheld devices but also from laptops.

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