

## Chapter XXIII

# Instructor Mobile Audience Response System

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## Abstract

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*This chapter describes a new class of audience response systems: an instructor mobile audience response system, or IMARS. While the typical ARS features mobile data entry devices in the hands of students and a desktop console for the instructor, the IMARS features a mobile device for the instructor and almost any device with a browser for students. The ClassInHand™ software, developed at Wake Forest University, is an example of a prototype IMARS system. It has the principal benefit that the system frees the instructor from being tethered to a desk during class, by turning a wirelessly connected PocketPC into a mobile teacher console. This chapter describes the basic components of an IMARS system, and discusses how it has been used in an educational setting.*

## Introduction

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The instructor mobile audience response system is a new concept that is based upon the standard features of an automated response system. Existing literature deals with either the ARS aspect or the mobility aspect, but not both. Our adoption of the ARS model is based on the teaching methods of Dr. Eric Mazur at Harvard, in which he describes the “ConcepTest” (Mazur, 1997), a multiple-choice question designed to uncover misunderstandings of a particular concept. As stated in the newsletter of the Vanderbilt University Center for Teaching (Fall, 2002): “One reason Professor Mazur’s teaching model receives so much attention is that he focuses not on ‘coverage,’ but on ‘uncoverage.’ The term ‘coverage’ refers to the familiar process of covering the contents of a course. ‘Uncoverage,’ by contrast, refers to the process of surfacing common misconceptions, and enabling students to see how complex ideas in a discipline or course fit together.” Audience response systems facilitate the concept test, and this teaching methodology.

What’s new about IMARS and ClassInHand™ is the focus on mobility for the instructor, a factor that is important to many faculty members who use the classroom as a theatre for student engagement. Most response systems require the instructor to be anchored to a console or display station in order to execute and analyze the response activity. Simply using a “mobile” laptop computer, rather than a desktop computer, does not free the instructor from the necessity to return, at regular intervals, to the teacher station to manage the system. While the laptop promised mobility for instructors and students, in the context of the classroom, it resembles a fixed computing solution. Others (Cain, 2003) have described the laptop as “luggable” rather than portable, and it certainly is not portable when acting as a response system that requires connectivity to a projector, network, or to special-purpose response systems. The IMARS moves the instructor interaction and control to a wireless PocketPC, a truly mobile device.

McLaughlin (2001), at West Virginia University, predicted: “Over the next couple of years, we should see a convergence of the PDA, wireless networking, and a broad array of useful PDA software. With this convergence the PDA will likely become a general-purpose information appliance, smaller and more portable but otherwise filling the same function as the PC. It will probably become an indispensable tool for students, faculty, and administrators in higher education.” This convergence began on the Wake Forest University campus in 2001, and accelerated with major improvements to the campus wireless infrastructure in 2004 (Dominick, & Bishop, 2003; Fulp, & Fulp, 2003). In addition, improvements in the PDAs themselves, particularly with the inclusion of embedded Wi-Fi and improved battery life, opened new possibilities to instructors for in-class experiments. With the increased acceptance of laptop computers as a standard student technology asset, general-purpose response systems that are Web-enabled become more important. In a ubiquitous computing environment, such as was available for the researchers at Wake Forest University, any classroom becomes an IMARS classroom instantly, with the simple addition of wireless networking and a PocketPC for the instructor.

## Architecture

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A typical ARS consists of at least three major elements:

1. A question presentation system that includes the primary interface for the respondent. Respondent interfaces may range from simple mechanical button-press systems to computer-driven touch-sensitive displays.
2. A results reporting system that provides the data to the instructor. The display may be in terms of unfiltered data, or may be displayed as graphs, or time-series data. More advanced software-based response systems will include an interface for the instructor to manage the response interaction. In particular, such a system will make it simple for the instructor to add, modify, delete, store, and retrieve both questions and results. Other tools may be included in the ARS that approximate online testing and quizzing systems. These features may include features such as user authentication to enable student-by-student assessment over time and randomized question presentation.
3. A processing system to deliver the questions, capture the responses, and perform any necessary storage or calculation.

The IMARS has all of these major components. In the implementation of ClassInHand™, the primary component providing question presentation and response collection is a custom designed Web server, developed especially for a mobile device based on the PocketPC platform. In this case, the respondent uses a Web browser on any Internet connected device. This eliminates the need for students to install and learn to use special client software or devices. In addition, students can submit free-form text, at any time, through the browser, as well as numeric input appropriate for a rating or opinion-based class activity. The index page for this mobile Web server presents links to all these types of activities, for easy access by students.

The storage system is comprised of files organized into folders within the My Documents folder of the PocketPC's file system. There are only three, stored, html pages: the index page mentioned previously, and the pages required for free-form and numeric input. Question text for concept tests and responses for all types of input supported by the application are contained in dynamically generated files organized into subfolders within the main application folder.

The results reporting system utilizes a custom-developed, lightweight, scripting language, and a custom CGI engine to process the scripting. This combination of scripting language and CGI engine controls the resources within the application, and manages presentation of dynamic html pages. Figure 1 illustrates the distribution of responses for the *quiz* feature in histogram form on the PocketPC screen, including both counts and percentages for each response. Responses for the *text feedback* and *numeric feedback* features are shown individually on the instructor's PocketPC screen immediately, upon submission.

Quiz results displayed on the instructor's PocketPC can also be shared with the class through a computer connected to the classroom projection system. This is accomplished by utilizing the classroom's wireless network to establish a communication link between the instructor's PocketPC, and a ClassInHand™ software component on the computer. This communication link also enables the instructor to browse the hard drive of the computer from his PocketPC, locate and start a PowerPoint presentation on that computer, and manage the slides by tapping on the PocketPC screen. This combination of controlling the lecture presentation, and receiving student input from the same mobile device, allows instructors to move freely about the room during the lecture and feedback activities, rather than being tethered to their desks to manage a console, and enables blending lecture and feedback based on pedagogy, rather than separating them into discrete activities based on the technology required for each. This sets the IMARS apart from typical Audience Response Systems.

The user interface for the instructor is comprised of four main screens easily accessible by tapping the appropriate tabs along the bottom of the PocketPC screen. The default screen is the Web Server (Figure 2), and contains buttons the instructor can tap to instantly start or stop the presentation and response system. Next is the Agent screen

Figure 1. Response display

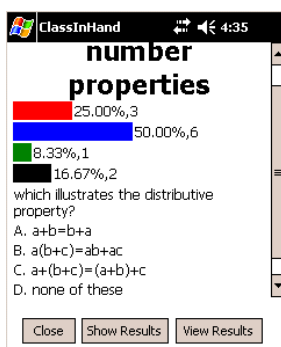


Figure 2. Web server

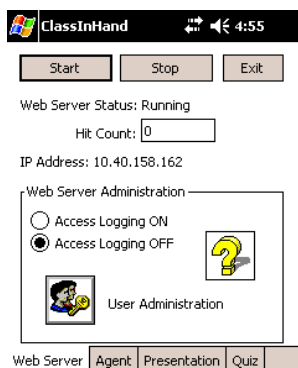


Figure 3. Agent

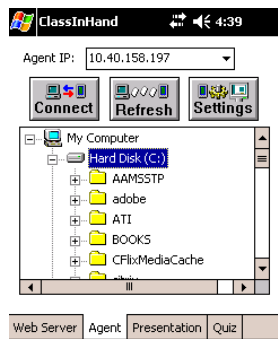


Figure 4. Presentation (text feedback)

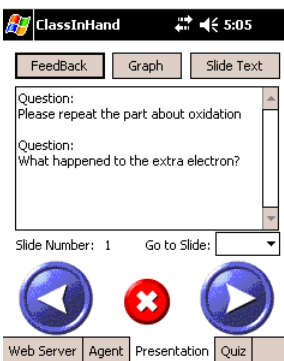
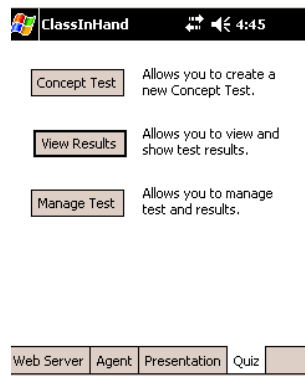


Figure 5. Numeric feedback



Figure 6. Quiz



(Figure 3), used for establishing the communication link between the PocketPC and the computer used for external display as described above.

Next is the Presentation screen. It contains thumb-sized buttons for managing the PowerPoint™ presentation and viewing its slide text and notes in the display area. By tapping on the Feedback or Graph buttons, respectively, the display area shows text feedback from students immediately upon submission (Figure 4), or numeric feedback in a continuous graph display format (Figure 5).

The Quiz screen (Figure 6) enables the instructor to drill down to subsequent screens to create and manage quizzes, either prior to class or on the fly during class. In the case of on-the-fly questions, it may be more appropriate for the instructor to reference an externally displayed set of questions, such as from a textbook, handout, or written on a chalk board, or simply a question spoken aloud. In these cases, the instructor may use the default (or blank) question. The quiz screen also has buttons for quickly managing which quizzes appear in the student's browser, editing test questions, showing results to the instructor, exporting results to a file, resetting results' totals to zeroes, and for displaying results to the class.

# Challenges

Developing software for the PocketPC platform presents challenges, among them processing power, memory, storage, and limited screen size for the user interface. Managing each of these challenges was critical to the development of a usable system.

We expected the processing power of the PocketPC to be a major limitation. Adapting a Web server to the mobile environment required selective implementation of customary Web server features. The Web server supports a specific subset of HTTP commands in a manner that is designed to enhance both speed and security. By taking advantage of

the PocketPC operating system's architecture, which supports multiple processes, each containing multiple threads, we were able to create a very powerful application that was both robust and secure.

Another challenge when writing applications for these small devices is the limited memory available. Unlike most Web servers, the ClassInHand™ Web server does not cache html or images, mainly because of memory constraints. We also created several of our own custom internal data structures when we found that those available as a standard part of the programming environment used too much memory.

Storage on the PocketPC is comprised of volatile memory, rather than hard drive space, as we are accustomed to. If the battery fully discharges, files are lost. To manage this potential problem, ClassInHand™ makes it easy for instructors to save quiz results for later analysis, anonymous text submissions for discussion or reflection, and signed text submissions for graded assessments. These files can then be synchronized or beamed to a desktop computer for permanent storage.

Developing a functional and convenient user interface with the limited real estate on the screen posed another potential challenge. Considering the advantages of a touch screen, we created buttons large enough to tap with either stylus or finger, and tabs to move among the four major screens. The instructor can quickly switch among functions within the application by simply tapping on the screen.

## **Pilot Projects**

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In order to evaluate the software, we engaged in triangulated studies in several classes. The study methodologies employed consisted of periodic surveys for students, class observations, and follow-up interviews with students and instructors. The subject classes were all undergraduate classes of between 15 and 100 students, in a variety of academic disciplines. The study periods lasted for an entire semester, and included training for both faculty and students. There was no compensation provided for study participants. A discussion of the classes involved in the project follows.

### **Physics**

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Our first pilot project was in an introductory level physics course of 100 students, held in a traditional, tiered, lecture-style class. The instructor had previously used the concept test approach to determine the level of student understanding in his classes, but he had done so by requiring students to record responses on index cards. When students held up their cards, the size of the class and the dynamic of the interaction prevented the instructor from seeing more than the responses for the first, two or three rows of students. He had neither an accurate count, nor a record of the responses, to help him determine the effectiveness of his presentation of the lecture material. Using the ClassInHand™ software, the instructor was able to get quantitative, digital feedback that he could use immediately. Additionally, the instructor could save the responses for later reference. His

students also used the text feedback feature of the software to pose questions during the lecture.

## **Chemistry**

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In this class of 40 students, the instructor tightly integrated concept-test quizzes with his lecture slides, and used ClassInHand™ on a regular basis in every class meeting. He typically started the class with a one- or two-question quiz using the text feedback feature. He gave students 2 minutes to complete the questions, and managed this by simply tapping on the screen to stop the Web server when time was up. Students signed their names to these submissions, and the instructor graded the submissions later. Most classes included two or three concept tests at logical points in the lecture. At the end of each class period, students submitted additional text feedback, anonymous this time, summarizing the most important point from the day's lecture, and indicating any points of difficulty. The instructor took this feedback very seriously, and found it valuable in directing the next lecture's starting point.

## **Educational Technology, Nutrition**

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In both of these classes, each with approximately 20 students, the instructor used the quiz feature of the software, but less often than in the sciences, due to the nature of the material. In addition, both of these instructors required students to do PowerPoint™ presentations on assigned topics. During each presentation, students rated their classmates' presentations using ClassInHand™.

## **Sociology**

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The instructor used primarily the Text Feedback feature of ClassInHand™ in this class of 26 students. At the beginning of each class period, she asked a question about the assigned reading, and had students submit signed, text responses. She could read the responses as they were submitted, and immediately address any misconceptions that were evident in the students' responses.

## **Mathematics**

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In two sections of calculus, each with approximately 35 students, the instructor used methods that required minimal setup on his part to assess student understanding of calculus concepts. He had only two questions built into his ClassInHand™ Web server: Do you understand? (with "Yes" and "No" as possible answers), and a blank question with A, B, C, and D as possible answers. After explaining a concept, he used the Yes/No question to determine what percentage of students felt that they understood the concept. If most of the class responded affirmatively, he followed up by quickly drawing four



illustrations on the chalkboard, labeling them A-B-C-D, and asking a question about the drawings that required students to apply the concept just discussed. Students used the A-B-C-D question to submit their answers. The distribution of responses either confirmed that the students did in fact understand the concept, or showed that they only thought they understood. In the latter case, or if students had answered “No” to the “Yes/No” question, the instructor could offer additional explanation.

## **Discussion**

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The experiment with the IMARS system at Wake Forest provided several interesting insights that relate to the pedagogical and technical aspects of mobile device utilization. Within the pedagogical realm, instructors utilizing automatic response technology must be able to, and prepared to, take action on the feedback that they are receiving. Technical issues are perhaps the most obvious factors related to any AR system, but in a mobile environment, the complexities of the technology assume a critical importance. The following sections will discuss these issues in turn.

### **Pedagogical Aspects**

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The particular IMARS system developed at Wake Forest was designed primarily to provide the instructor with a flexible, mobile control tool for the classroom. A key component was the ability of the instructor to receive instantaneous response on his/her handheld. As noted before, this response could be through the numeric feedback, a quiz, or through text response. The key advantage of a mobile AR system is that the feedback system is more naturally a part of the instructor's environment. Instead of having the information display located at a fixed teacher station, the feedback follows the instructor, who can see the feedback privately on their device while teaching the class. Further, as the device is used for classroom control activities such as controlling a PowerPoint™ presentation on a projector-connected PC, feedback presented on the device is more likely to be seen by the instructor throughout the class. As such, it makes it more likely and more natural for the active instructor to engage feedback. The feedback activity that we observed in our experiments highlights several points worthy of discussion.

In all of the classes that we observed, the primary method of feedback for instructors was through the quiz feature, in the spirit of Mazur's concept test. This form of feedback was immediate and focused. The purpose was to assess student knowledge of a particular issue. It provided an electronic parallel to paper quizzes or hand-raising, but with the benefit of fast response and anonymity. As such, it fit well within the paradigm of faculty expectation, and was relatively well received by faculty and students alike. The potential benefit of an electronic recording of “ad hoc” quizzes was described by one of the instructors in the following manner:

*I think by institutionalizing this, by incorporating it in a formal way into the course and saying, before you leave class you must do this, I think that will do much to improve the course in two ways: (1) it will allow me to immediately address in the next class deficiencies in the way I communicate to the class; and (2) once again it will improve my course from semester to semester. I will see these are what the responses were and this was good, that was bad. And so the things that worked, I'll keep, the things that didn't work, I'll trash and find another way to approach it.*

The important element was that the automatic response allowed the instructor to obtain immediate and actionable feedback that could be used to improve the teaching of the class. It was useful for addressing particular issues, but in addition, the process of *experiment, evaluate, and correct* is facilitated via the electronic technology because it is easier to record, store, and manipulate the data. These are aspects that would apply equally to mobile response systems and fixed response systems.

More challenging to the faculty was the ad hoc text based feedback. Because the feedback display system is carried by the instructor, he or she is more likely to interact with text feedback in unplanned situations. When presented with ad hoc feedback, or by a response such as "I don't understand", an instructor is faced with the necessity of making multiple decisions very rapidly. First, for a single piece of text feedback (the typical case in our study), the instructor must quickly assess whether this is a widespread feeling, or whether it is an isolated experience. Second, the instructor must decide what action, if any, to take. Third, the instructor must balance the time spent on addressing the question, with the objectives of the syllabus. Finally, instructors wishing to encourage response and feedback in the classroom feel reluctant to simply ignore difficult feedback, for fear of providing negative reinforcement.

In our study, we found that unsolicited text feedback produced difficulties for instructors who were not prepared for such events. As opposed to the structured responses from quizzes, as noted prior, which have finite possibilities, informal feedback is an event that has no defined response set. The instructor has to make snap judgments about what to do. This can be uncomfortable for an instructor even if he/she is prepared for it. One thing an instructor can do to manage freetext feedback is to set expectations correctly at the beginning of class, informing students as to whether feedback will be viewed and acted upon immediately, or reviewed after class.

It is important to note that in all cases where feedback is sought, the instructor must carefully consider the impact of that feedback. In courses which are linked to a tight time frame, such as many introductory courses with common syllabi, the instructor faces a difficult choice. If he/she acts on the feedback, the risk is that some other topic in the class will suffer in its time presentation, and that the students will be at a disadvantage in their later courses or on a common examination. If he/she ignores the feedback from the student, the entire purpose of the feedback system is compromised. These are issues that apply to all classroom response systems.

In all of our pilot classes, the instructors felt that the anonymity of the responses was an important feature of the software. Students were able to respond honestly without fear of exposing their uncertainty or lack of knowledge to either the professor or their classmates, and thus were not hesitant to participate. They viewed this as a self-test

where they could determine their level of knowledge without affecting their grades. For occasions when nonanonymous feedback was important, instructors had students use ClassInHand™'s text feedback feature, and simply sign their names to the submissions. One of the instructors who used both signed and unsigned feedback remarked that he received more communications from students through ClassInHand™ than email, because students were sometimes hesitant to reveal their identities when asking a question. In no case was submission of inappropriate material a problem.

## Technical Issues

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In our studies, we found that there were several technical challenges presented with an IMARS device. Because the device is battery powered, power consumption becomes a critical factor influencing the utility of the device. It is possible to plug the devices into a charging station, but this decreases the mobility, and hence the spontaneity of its use. The built-in power management features of PocketPC proved to be a hindrance, rather than a help, in using ClassInHand™. As can be expected, battery life dropped significantly with extensive display and wireless network use. We learned in early testing that the power saving features must be turned off prior to use in class: otherwise, when the instructor's PocketPC Web server went into power-save mode, students lost their connectivity to the response system. Because use of wireless connectivity drained the battery at a relatively fast rate, early PocketPC models ran dangerously low on power during one 50-minute class period of continuous use of ClassInHand™ for both ARS functions and controlling PowerPoint™ slides. In virtually every course, on at least one occasion, the instructor was unable to use the device because the batteries had been depleted. Instructors in our pilots learned quickly that to be successful, they must not only disable the power-saving features of the device, but also make sure they started classes with a fully-charged battery. As with any classroom-based system, repeated technical problems lead to perceptions of unreliability, and eventual rejection of the device. While there were periodic technical problems in each of the classes studied, none were severe enough to cause complete rejection. Battery technology has improved greatly since our first pilot in 2001, and a fully-charged PocketPC with power-save features turned off can now easily be used for an entire lecture period with power to spare.

We had anticipated that there would be performance problems with the device during intensive feedback sessions. However, careful planning and attention to programming details mitigated this potential problem. Test results have shown that in one minute, the ClassInHand™ Web server can take as many as 15,015 hits using 25 threads with no socket errors. We did not see any limitation in processing power in any of the pilot classes.

Also, there were no major problems presented by the limited screen space available on the devices. Initial concerns about using a small-form factor device were that the controls and feedback would be too small to read by instructors. The ClassInHand™ software was designed to provide an easily navigable interface, with large icons to facilitate quick orientation on the screen (Figure 5). Quick orientation is important because the device is typically carried by the instructor in whatever manner is comfortable, and brought up into view when demanded by the situation. Being able to rapidly find the necessary function on the device is a key component in making the use of the device effective in the class.

The unique capability of the instructor mobile audience response system is that the entire experience is mobile, depending only on the presence of a WiFi network, rather than desktop computers or wired keypads. Because students connect to the instructor's mobile Web site to provide responses, it is even conceivable that the software could be used in a distance-learning environment, where the students at remote locations are participating synchronously to provide feedback to the instructor.

## Conclusions

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ARS systems can be valuable to an instructor who wishes to inform his practice, and is willing to make the adjustments that such a teaching style requires. The key aspect of the IMARS system is that the response system is mobile, and part of the instructor's personal space. Unlike fixed systems, an IMARS implementation, as demonstrated by ClassInHand™, allows the instructor to gather response from the class without compromising her classroom technique. As with all response systems, the instructor must be both prepared to, and capable of, acting upon the data that is received. The relative immaturity of handheld computing technology provides some implementation challenges, but the problems are likely to be short term rather than endemic. With the increasing availability of super, small, mobile computing devices — from laptops to Web-equipped cellphones — instructors will be able to engage students in both ad hoc and planned feedback activities without the need for large-scale investment in fixed response systems. This will particularly be the case as the classroom experience itself evolves from the traditional fixed-seating environment to an environment that is dynamic in its space.

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