# What's our favourite colour? Using Bluetooth-enabled mobile devices for group decision making


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## ABSTRACT

In this paper, we present an audience response system (ARS) using ubiquitous devices, specifically Bluetooth-enabled phones. It is proposed that the system can act as a replacement for costly proprietary products such as TurningPoint clickers and Keepads. Such a system is attractive as it reduces the cost to both the audience and the presenter. Through experiments in real-world environments, we found that the system may have limitations, however the minimal configuration system presented here performed well in a small group setting.



## Categories and Subject Descriptors

H5.2. [**Information Systems]**: User Interfaces – *Interaction styles.*

## General Terms

Performance, Design, Experimentation, Human Factors, Standardization

## Keywords

Audience Response Systems, Electronic Response Systems, Ubiquitous Computing, Mobile Devices, Bluetooth.


## 1. INTRODUCTION

Student engagement is almost a requirement of teaching and learning. Getting students engaged in a face-to-face learning environment, particularly in large lectures with potentially hundreds of students, has difficulties and often results reduced student attention, and worse, lack of attendance. Attempts have been made to enable more interaction via specialised devices (i.e. TurningPoint Clickers [1]) which require purchase of the devices by either students or institutions.

A useful example set in an educational environment is Tsvetinov, Abercrombie & Do's 1995 study of the use of KEEpads with first year students to get them talking together without the "bounded rationality" which typically occurs with group thinking [2].

The implementation of these types of systems is starting to occur, however the cost to some institutions may be prohibitive. There is the possibility that this cost will be transferred onto students. In this paper we argue that the purchase and use of these devices is becoming redundant, considering most students have either a Bluetooth enabled phone or computer. We also argue that proprietary systems have some known limitations, e.g. TurningPoint can only communicate through infrared line of sight technologies. This limitations specifically makes them unsuitable for at least one of the scenarios presented here.

Thus we present a design concept for an audience response system (ARS). We present the minimal technical requirements, three proofs of concept, implications for design as well as suggesting future work through illustrative scenarios. The design presented attempts to utilise ubiquitous devices and enable convergence of applications within a single device.

This paper investigates the following design questions:

- How can ubiquitous devices be used to collect information in a real time educational setting?
- How can the gathered information be used to make decisions in real time?

In line with the aims of this proof of concept, Freeman et al [3] suggested that a Bluetooth-based audience response system would better integrate with student lifestyle decisions, and this is based on the work of Prensky [4] who suggested a system which would allow students to SMS responses to set questions. These systems and the one presented in this paper attempt to harness the integrative capacity of using every day ubiquitous objects (mobile phones) in novel ways.

Pering's [5] Musicology project explores using mobile (cell) phones as conduits for social music use. He presents three different interface modalities: public (others can see who they are), anonymous (unidentified interactions), and registered, where a personal digital profile is used. These three interface modalities may be linked to the concepts presented in section 2.1.

Finally, in some ways similar to our research, Valkkynen and Tuomisto [6] present a proof of concept of a mobile-device based interaction method for pervasive computing. In defining these user interaction methods for physical browsing, they present scenarios for their use. They agree that scenarios are a useful way to present a proof of concept.

Building on these examples and in looking at the wider applications for this technology, the system potentially moves beyond classroom/lecture hall scenarios to enable decision support systems for meetings, particularly Annual General Meetings (AGMs) where large groups of people are involved in voting.

# 2. INITIAL CONCEPTUALISATION

## 2.1 Concept

The concept is for an 'Audience Response System' (ARS) to enable participants in a lecture to respond to questions via a Bluetooth enabled phone. The envisaged system would allow for responses to be tallied and the information available immediately for discussion.

The system would require some configuration, however, there is potential for a minimal amount of pre-configuration. The obvious reason for this being setup time needed in a 50-minute lecture environment, and managing the configuration concurrently across a large group of students.

There exists the potential for three levels of configuration. In the (mobile) sending device:

1. Minimal – Bluetooth capability in 'discoverable' (Macintosh term) or 'shown to all' visibility (Nokia term). Devices with different configurations may also be used although further steps may be required.
2. Context aware – a Bluetooth-enabled device to send data, specifically pre-downloaded vCard with programmable responses (yes/no, multiple choice options, very short answer (one-two words) responses) using object push (OBEX).
3. Feedback system – a system where simple responses can be sent to a specific device provided the device name is known (for large group scenarios). May require vCard type interface where name of receiving device and response is input.

For the minimal configuration scenario, which is presented here, an Apple Macintosh MacBook portable computer with Bluetooth capabilities was used as the 'receiving' device. The built in "Browse Device" command was used to scan for operating Bluetooth devices. For the more developed systems, the receiving end could consist of:

- Computer with software which can scan for Bluetooth devices
- Process for dumping responses to a text file
- Script for parsing responses and importing text file into spreadsheet or similar and using simple graphing processes (scriptable or based on simple functions – e.g. COUNTIF, then function REPT to give simple graphs see example in Figure 2).

## 2.2 Minimum Configuration

The configuration of the developed system would require:

- Bluetooth scanning
- Script to count number of connections (population)
- Script to import data to spreadsheet

In a minimal (nil) configuration, the receiving system would scan for active Bluetooth signals. Respondents would turn Bluetooth on and off to send a response. This configuration would require no installation on the remote (mobile) device and would utilise basic sending capabilities on their device. The receiving station would observe active Bluetooth signals and provide a count of signals during a set period of time. Respondents would activate their Bluetooth functionality in response to a set of answer choices provided by the presenter/lecturer/assistant.

A more advanced system, perhaps using vCard systems, would provide for multiple responses. The vCard would contain the response, perhaps input by the respondent at the time of the interaction. This response would be read by the receiving station and then processed. This would enable a list to be imported into the spreadsheet.

A fully developed system may be able to take multiple choices then return raw numbers of responses or simple graphical representations of responses.

## 2.3 Scenarios

A number of potential scenarios are presented to assist in the potential configurations of the system. These scenarios are based on basic uses of the system. As development progresses, more advanced uses may become obvious.

### *2.3.1 Lectures*

Students can respond during lectures in order to provide real time feedback to instructors. This feedback may be used to inform the lecturer or their assistant on levels of understanding of content they are teaching. In a similar manner to TurningPoint, students could respond to multiple-choice questions, yes/no questions and potentially a single word response (this would be in the more advanced system and perhaps generate a cloud of responses, in a similar manner to tag clouds, common in web 2.0 technologies). This system potentially allows for discussion of key perceptions of participants (students) as they are being challenged with new information.

One major benefit of this system is to encourage student's learning by being active participants in class. Having a pseudo-anonymous input might allow those to respond who might otherwise not raise their hand in class to answer questions.

### *2.3.2 Meetings*

With questions and issues raised during meetings, members in attendance could be asked to respond. This could help to anonymously determine the level of consensus of controversial issues, as well as being used in voting situations. Participants would be able to provide yes/no responses, which could be analysed precisely and relatively quickly. During the meeting the results could be disseminated to all participants.

## 2.4 Design

Based on the scenarios presented, we suggest 3 levels of design:

1. One-way response system. This system allows answering of simple questions with no configuration by participants. In a classroom/lecture, the presenter could ask a question, request participants to respond if agreeing (or disagreeing), then tally the responses.

    - Example: Please turn on your Bluetooth if you like the colour blue. A second request could be: Please turn on your Bluetooth if you do not like yellow. The system would tally responses and present them as either raw figures or with some scripting a graph or percent. This provides real data for participants to engage with in discussion.

2. Programmed response system. This system could use a vCard with a small number of responses able to be sent. Participants would be able to respond to multiple options by additional input to the vCard and maintain their active Bluetooth for the response. The system would tally totals for each response

3. Two-way response and feedback system (in real time) A more advanced system could feed tallied responses back to devices. In this case, the system as described in point 2 could be programmed to respond with a simple vCard back with totals for each response.

This proposal deals primarily with the basic level for participant interaction and graphical display of input.

## 3. Proof of Concept

Trials were conducted based on availability of groups of different sizes. Thus the initial trial was conducted with a small group who meet regularly for research discussions. The second trial was conducted with a large group of first year students (approximately 100). The third trial was conducted with a smaller group of postgraduate students (approximately 20). Precise numbers of participants in these groups is not known due to a limited window for testing (at the end of a lecture) and the presence of some individuals without phones who were interested in witnessing the test.

### 3.1 Trial 1

The first trial was conducted using an academic audience of primarily information technology and information systems lecturers in a controlled meeting environment. Eight individuals with Bluetooth capable phones participated. These participants were able to test out various ideas and situations and provide insight into ways in which students or other participants may react in a given situation.

In our initial trial with these participants, we were able to gather some responses to different questions. We used a MacBook with Bluetooth capability as the base station. Figure 1 shows the Bluetooth scanning in response to a question.


**Figure 1. Scanning for participating Bluetooth phones. The list of devices is hidden to protect participants' details.**

The responses were read from the browse files screen (Figure 1) and entered by hand into a spreadsheet to provide a quick graph using the REPT function. Figure 2 shows the charted responses to the questions in table 1, which were used in our proof of concept.

### 3.2 Trial 2

The second test was conducted at the end of a lecture with a group of first year students. While there is 300 students enrolled in the course, not all stayed for the test nor were all those present in possession of a phone. Thus the precise number of participants is unknown.

This test provided valuable information about the limitations of the proposed system using generally available equipment. One significant limitation is the scanning system used by the Macintosh MacBook as the base station. This system not only scans for devices, but also collects ID information. The length of time the numbers are available to the operator of the system was insufficient to establish the number of devices transmitting.

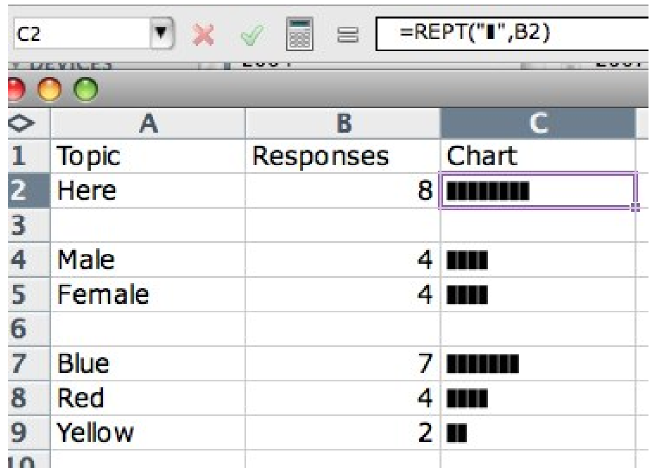


**Figure 2. Spreadsheet showing recorded and graphed responses using REPT function**

| Question number | Question | Row number of response in Figure 2 |
|---|---|---|
| 1 | Please turn your Bluetooth on. | 2 |
| 2 | Please turn your Bluetooth on if you are male. | 4 |
| 3 | Please turn your Bluetooth on if you are female. | 5 |
| 4 | Please turn your Bluetooth on if you like blue. | 7 |
| 5 | Please turn your Bluetooth on if you like red. | 8 |
| 6 | Please turn your Bluetooth on if you like yellow. | 9 |

**Table 1: Questions asked of participants**

A second limitation of this trial was the large venue. This venue is the largest lecture theatre on campus and is set out in a layered style from the front to the back of the room, much like an auditorium where participants are sitting level to higher than the presenter. As a lecture theatre designed to hold more than 400 people, the distance may be a limiting factor in the final design of the system. During the trial, the receiving station (MacBook) was moved to the centre of the room, where 35 devices were recorded. The system then went into collecting IDs so perhaps there is a limitation in the design of the Bluetooth scanning system.

From this trial, we learnt that the final system may need to be limited to scanning rather than collecting ID signals. However as a trial, the system performed some of the functions.

### 3.3 Trial 3

The third trial was a smaller venue (maximum capacity 180). This trial was smaller (14 students with devices) and the students were advanced masters students. At least one student already had a degree in IT and was interested and helpful in conducting the trial. For this trial, students gathered around the podium and answered the same questions as Trial 1. Students then walked away from the podium to test range. It was found that most signals dropped out before students reached the back of the room.

From this trial we learnt that while the system has potential, a more powerful receiving station and more powerful broadcasting appliances may be needed for a workable system for large groups.

## 4. DISCUSSION

Based on the testing of our proof of concept, the system appears to be able to work manually with some caveats. While the trials asked only for positive responses, questions could potentially cover negative responses and neutral responses. This was an issue raised by one participant in the initial trial.

Issues that were raised by participants during the first trial included both technological and social issues:

- Auto-discovery is not a function one all phones – on participant's phone has to be selected as 'find me' (Motorola) in order to be found.
- Participants may be engaged in another activity on their phone, which automatically turns on Bluetooth (i.e. sending files from their phone to their computer via Bluetooth) – this occurred with one participant.
- Access to a mobile phone device and its required features – one participant's phone battery went flat, although for this trial we had access to more phones.
- Framing of questions - How to tell between the no's and those who don't want to answer. How to get people to participate. If they don't care and don't respond then is it assumed that they are saying no?

These issues need further investigation.

Another significant issue, which became evident during the trials, was the slow response times of the Bluetooth scan as it attempted to extract the names of the devices. This was particularly evident during the larger scale trial (Trial 2) which could be counted as a failure. In a fully designed system, the scanning ability of the Bluetooth may need to be restricted to providing a simple count of devices, rather than any sort of identifier. This is theoretically possible but not with the unmodified applications at our disposal. A simple count could then be sent to the current (active) cell in the spreadsheet thereby allowing instant feedback to be presented to participants/presenters. In the regular course of a teaching session, this then becomes the discussion point for the class.

## 5. IMPLICATIONS FOR DESIGN

The design of a system such as proposed here depends on environmental factors such as room size, location (incl. interference from outside sources), number of participants, reliability and strength of the receiving station as well as the sending devices. The application developed to run such a system would require some design in order to facilitate even a minimalist approach. Once this is achieved, a more integrated interface could be designed.

## 6. CONCLUSION

Engaging students in large classroom environments can be a challenge. Generally the attempts to do this encourage students to be more active in contributing to discussions and in providing feedback in real time.

In this paper, we present a conceptual design, which attempts to utilise ubiquitous devices and enable convergence of applications within a single device. The design could be implemented in either a small classroom or a large lecture theatre environment with appropriate equipment. We present another situation, that of an Annual General Meeting, in which the design could be applied.

We also present a working proof of concept effective in getting responses from participants however the test highlighted that some issues need to be investigated further. Design of the system appears to be within the scope and capabilities of Bluetooth, although further tests to determine the maximum number of concurrent connections possible need to be performed.

Discussions with software engineers and technologists have been fruitful in confirming some assumptions about how Bluetooth could work to achieve this.


## 7. ACKNOWLEDGMENTS

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