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Interactive Lectures: Encouraging Student Interaction Using Quick Response Codes

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Abstract— This article presents an ongoing project to encourage student interaction during lectures through the use of Quick Response (QR) codes and Google forms to generate rapid response polls and quizzes. Audience Response Systems (ARS) are generally expensive to purchase, require students to purchase a clicker and need to be installed in a dedicated room. This article proposes the use of Google applications (Apps) software combined with the students' own smartphone as a viable free alternative to the current clicker systems. An investigation into the pedagogical issues associated with such a project will be explored and an attempt made to incorporate these into the student experience. The overall process from the creation of the software to the roll out and use of the software in an interactive lecture, the issues encountered and participant feedback will also be described.

Keywords- QR Codes; Student Interaction; Feedback.

I. INTRODUCTION

The initial paper of this work [1] outlined the combination of readily available, and to certain extent, free technologies that could be combined to enhance the students' and lecturers lecture experience.

Smartphones in the UK, and elsewhere, have seen a surge in popularity over the last few years evidenced by recent figures showing "Over half of the British population (50.3%) now owns a smartphone" [2]. A survey conducted by Deloitte [3] in the UK during the early part of 2014 points to a quite considerable rise in smartphone ownership. Deloitte's survey indicates that smartphone ownership is up 10% between 2013 and 2014 leading to almost 80% of households in the UK owning at least one smartphone. This surge in ownership strengthens the belief that the smartphone has become a ubiquitous technology.

Edinburgh University recently conducted a survey of their student population determining that 67% had ownership of a smartphone "an increase of seventeen percent from those students surveyed seven months earlier" [4]. This uptake in smartphone ownership within the student population opens a new dimension for interaction.

A tangible increase and use of Quick Response (QR) codes by many companies as a form of marketing has ensued on the back of this increase in smartphone popularity. This has allowed many companies to develop new and engaging

ways for their customer base to interact with products in situ reinforcing brand presence. This potential has already been harnessed by Education to extend learning materials through the use of QR codes. Learning materials have been enhanced by providing "just in time support materials" [5] such as videos, explanatory text, Uniform Resource Indicators (URI) and staff details.

Using this as a platform to build from the next logical step is to combine the technologies to allow students to interact during lectures through quick multiple choice based questions. The students' responses can be compiled to show the result in a timely manner [6].

The remainder of this article is organized as follows: Section II gives information about pedagogical issues related to interactive lectures, Section III introduces the technology used for implementing interactive lectures; this covers both hardware and software. Section IV discusses the author's experience of implementing interactive lectures, while Section V discusses issues encountered during the interactive lectures. Section VI discusses selected feedback garnered from a student survey. Section VII offers a summary of our experience of interactive lectures, and concludes the article giving proposals for future work.

II. PEDAGOGICAL ISSUES

Take a typical lecture; what does this encompass? Information is imparted upon the student in a relatively one way passive communication format. This traditional didactic approach is a format that has been used for centuries. This research intends to explore the possibility of improving and enhancing the lecture experience through the use of technology, and in particular, Audience Response Systems (ARS). The ability of such systems to encourage active learning through student participation and engagement provides an opportunity for enhancing the passive lecture format by introducing two way interactions with the student audience [9].

Murphy and Sharma further suggest that the research literature available for the topic of interactive lectures and the related pedagogical issues are "almost non-existent, with major issues waiting to be examined... inadequate research on the pedagogical implications of the emerging interactive

forms of learning” [9]. With this in mind there appears to be an opportunity to examine and suggest how ARS technology could be used to not only enhance lecturer-student interactions, but also develop the underlying pedagogical issues inherent with lectures.

The concept of “Deep and lasting learning” as postulated by Boyle and Nicol [10] is enhanced when students have the ability to “actively engage” with what they are learning, allowing them to “construct their own understanding”.

The theory of punctuating a lecture is not new as evidenced by Angelo and Cross [11] and the concept of the “minute paper” whereupon the student body is asked to answer the question “What was the most important thing you learned during this class?”. The students take the last few minutes of the lecture to answer this question giving the lecturer important written feedback. This method allows the lecturer to gauge how well the students have understood the delivered content but the timeliness of the feedback is not effective for the student.

ARS technology provides a means for the lecturer to engage and interact with the students using the responses to offer the student audience immediate feedback. This should lead to further discussion and the opportunity for student reflection. Other research, reported in Murphy and Sharma [9], identifies two pedagogical aspects of interactive lecturing: dialogic form of learning and active learning.

The project intends to examine these issues and the resultant effects that they have on the student audience. The primary concern is that the interactive lecture will stimulate engagement and interaction with the student audience and the lecturer through the use of instant feedback. This feedback will engender in both the student audience and the lecturer the need for reflection on many aspects of the material delivered and possibly the module in general. Through the use of relevant and targeted questions the students can be cajoled into discussions that will help expand their understanding of the topic area. Through these discussions both the students and the lecturer will be able to better understand the level of the students understanding of the subject area.

Gannon-Leary et al. [7] reported a number of other positive aspects to arise from interactive lectures including improved concentration, greater enjoyment and improved attendance. Simpson and Oliver [14] also noted that the anonymity provided by ARS technology played an important part in encouraging students to contribute to answering questions but suggests, as does Gannon-Leary et al. [7], that the design of the questions is very important to the process.

Saravani and Clayton [15] have developed a conceptual framework referred to as A.C.E. This framework is composed of the three A’s: Awareness, Action, and Accomplishment; three C’s: Context, Content, and Capability; and the three E’s: Enabled, Engaged, and Empowered. The three E’s aspect of the framework fits the concept driving interactive lectures as the use of mobile technology enables, engages and empowers both the student body and the lecturer.

Devon and Law [21] have mooted a framework of five stages which they believe are required “to maximize the benefit of the technology”.

Table I shows the framework noting the “Process”, the participant “Who” and the point at which each step takes place. This table highlights the need to prepare the question prior to the lecture. The preparation of a carefully crafted question will maximize the benefit of its use for both the student’s understanding and the lecturer’s ability to ascertain relevant feedback.

TABLE I. DEVON AND LAW FRAMEWORK

Process	Who	When
BUILDing the question	Lecturer	Before
ASKing the question	Lecturer/Student	During
CONSIDERing the question	Student	During
DISCUSSing the question	Lecturer/Student	During
EVALUATEing the question	Lecturer/Student	After

The framework proposed by Devon and Law [21] is influenced by Beatty et al. [22] question driven instruction (QDI). QDI suggests that the process of crafting a question that elicits the maximum benefit for the learner, asking this question, allowing the learner time to process the question and answer the question before facilitating a discussion based around the answers given is a “key vehicle for learning”.

Sandhu, Afifi, and Amara [23] assert the need to grab the learner’s attention and subsequently hold their attention is a key aspect of any interactive lecture. They continue to propose that questioning, discussion and timely feedback are core to effective lectures.

A common theme highlighted by a number of researchers [7] and [14] is the need for well-designed questions and their correct placement within the lecture. If the questions are poorly construct and or badly placed within the lecture this will negate any perceived benefit from the use of the interactive system.

Ramsden [5] suggests, amongst other things, that Quick Response (QR) codes can be used for “just in time information in a face to face lecture”; drawing on this point allows for the expansion of the concept to include feedback for both the student and the lecturer. Mooted by Law and So [17] is the idea that QR codes can facilitate a “trinity of “location independence,” “time independence” and “meaningful content””. Of interest in this “trinity” is the idea of “location independence”; being able to deliver and receive feedback to and from the students in the lecture hall.

Both Dufresne et al. [12] and Crouch and Mazur [13] indicate the use of interactive lecture systems, whether as clickers or the system proposed here, can help facilitate opportunities for in lecture student discussion and as such improve the students’ retention and understanding of the topic delivered.

III. TECHNOLOGY

ARS systems are available in many forms and price points. A typical classroom package can cost \$1000 or more

for software, receiver and 12 clickers [18]. Some systems require the student to purchase a clicker and yearly registration at a cost of \$20/\$15, respectively [17]. This project developed a “no cost in-house” system that was based on three key components: smartphones, QR codes and a Google spreadsheet. No proprietary software for the phone is required simply a standard browser and bar code reader. The “back-end” is relatively simple to create as the implementation interface is supplied by Google.

A. Hardware

The student participants referred to in Section IV were surveyed to determine the spread of handset manufacturers and phone operating systems. Around 50 students were surveyed.

Figure 1 shows the spread of handset manufacturers and Figure 2 shows the spread of phone operating systems with the surveyed population.

With such a range of manufacturers and operating systems an “app” based solution would be time consuming and prohibitive. With further investigation, it was discovered that third party barcode reading software was available for all the platforms, thus allowing the students to use their own phones for participation in the lectures.

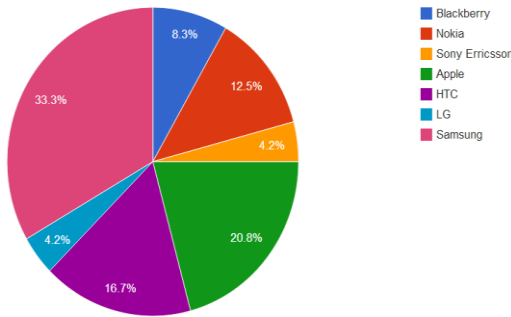


Figure 1. Spread of manufacturers

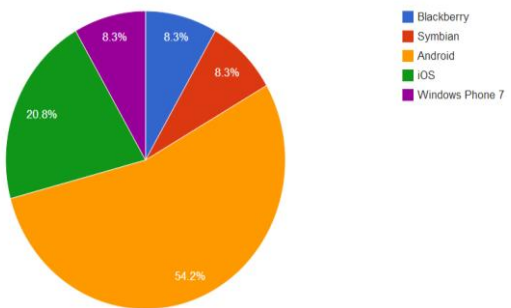


Figure 2. Spread of operating systems

B. Software

The software can be split into three categories: third party barcode reading software, third party browser software and the development of the interactive engine software using Google spreadsheets. It was up to the students themselves to decide on a suitable third party barcode reading software, although some phones did have such software preinstalled.

Three components of Google spreadsheets were used in the creation of the software application: the spreadsheet, the form and Google Script.

The spreadsheet itself is used as a repository for the student responses and also to house a summary sheet which keeps a running total of the number of responses for each possible answer to the question. The work horse of the system is the form and the scripts generated to process the responses at the back end. When a spreadsheet is created using Google Drive, a unique identifier is generated to identify the spreadsheet. When the subsequent form is created for the spreadsheet, another unique identifier is generated.

Although Google forms can handle a number of different inputs, the decision was taken to keep the question to a simple multiple choice style question, thus presenting the student with two or three QR codes per question. To create the QR codes requires the compilation of an http request based on the URI for the Google spreadsheet and the data to be sent to the spreadsheet. Once the http request was constructed and tested an online QR code generator was used to generate the required QR codes. These QR codes were subsequently saved as image files for insertion into the lecture slides.

Google script was used to create code that processed the student responses as they were received to generate a response summary that was visible to the student audience.

C. Code Explanation

This section will provide an examination of the code used to build the application. Before coding the application began an understanding of how Google compiles and uses query strings to transfer data between the application and its servers is required. The application hinges on the query string being built correctly.

Automating the process to build the QR code means that no prior knowledge of how to use or create QR codes is required, thus, widening the access of the tool.

Google provides a number of Application Programming Interfaces (api's), one of which, is the chart api. This api is accessible in a number of different ways, but for this application a direct call will be made to the chart api which is located at Google.com.

A bit of reverse engineering is required to understand the composition of the Uniform Resource Locator (URL) generated by entering data in the Google form. An example URL is shown in Figure 3.

The string contained in the spreadsheet at cell C6 uses the spreadsheet, concatenate function, to combine a number of strings and data from different cells. The first part of the string that forms the URL, "https://docs.google.com/spreadsheet/formResponse?formkey=", has two distinct parts. The "https://docs.google.com/" refers to the location that Google stores it's "docs" suite of apps. The "spreadsheet/" refers to the particular application from the suite that will be used. The next part is important,

<https://docs.google.com/spreadsheet/>
 formResponse?formkey=dEdDWThidGNEMkVMSzhfbGI1cGNpRXc6MQ
 &ifq&
 entry.0.single=Pequi
 &submit=Submit

Form key – unique to form/spreadsheet combination. (points to the formkey value)
Value – store in spreadsheet. (points to the value Pequi)
Entry – indicates only one entry allowed. (points to the .single parameter)

Figure 3. Example URL

this is the query string that tells Google the required processing that its server needs to perform. The "formResponse?formkey=" indicates that the subsequent data following the question mark comprises the response to a form. This is the data that would be generated and sent if the user had to fill in a Google Form. The first parameter after the question mark is "formkey"; this is vitally important as it refers to the unique identifier given to the spreadsheet by Google when it was created. This value is stored in cell B1. Each parameter is always separated by an ampersand. The next parameter "&entry.0.single=" indicates that a single entry of data is required. This means that the data has been limited to a single piece of information. The value of this data is stored in cell B6. The final parameter "&submit=Submit" is used to signify that the data entry is complete and is now ready for processing. The URL generated by this process will subsequently be used to generate a QR code that the user will scan using their phone.

The composition of the formula to produce the QR Code is based on the nesting of spreadsheet commands.

```

=IMAGE(CONCAT("http://chart.apis.google.com/chart?cht=qr&chs=350x350&chl=", encodeURL(C6)))
  
```

Figure 4. Example Spreadsheet function to create QR Code.

The CONCAT command is used to join two strings together. The first string is the reference to the Google chart api; it is a parameterized string containing the minimum parameters required by Google to correctly generate the specified chart type. Breaking down the string, "chart.apis.google.com" points to the location online where Google stores its chart api code. The following part of the string specifies the parameters required for generating the desired chart type. The "/chart?" indicates that a chart is required. The parameters that follow make up the response string that will indicate the desired chart type, size and data to be encoded in the qr code, each separated by the use of an ampersand. The "cht=qr" indicates that the chart type will

be QR. The "chs=350x350" indicates the size of the QR code to be generated. In this instance the size will be 350 pixels by 350 pixels. The "chl=" indicates the data that will be encoded as part of the QR code. This will be determined by the concatenation of the second string. The second string is contained the spreadsheet at cell C6. The string stored at this location will be used as a web address; it is advisable, therefore, to use the function encodeURL to ensure the correct encoding of the string as this will have a crucial affect when the QR code is subsequently scanned and an attempt to access the web address is made.

The scripts for the prototype are relatively simple in their construction. The example in Figure 5 shows the use of six global variables and a controlling method called runChart().

```

1 // Variables accessible by all functions in the code script
2 var sheet = SpreadsheetApp.getActiveSpreadsheet();
3 var sheetActive = SpreadsheetApp.getActiveSheet();
4 var dataSheet = sheet.getSheets()[0];
5 var summarySheet = sheet.getSheets()[1];
6 var summaryRange = summarySheet.getRange("a1:b5");
7 var chart = sheetActive.getCharts()[0];
8
9 function runChart(){
10   if ( sheetActive.getCharts().length == 0)
11   {
12     createChart_();
13   }
14   else
15   {
16     updateData_();
17     modifyChart_();
18   }
19 }
20
  
```

Figure 5. Variable Declarations and Controlling Method.

The global variables are used to make the code more concise. These variables rely on Google script commands to access various aspects of the spreadsheet. The first variable on line 2 determines the active spreadsheet; the second variable on line 3 determines the active sheet within the active spreadsheet. The variables on lines 4 and 5 are used to target specific sheets in the active spreadsheet. Line 4 refers to the sheet containing the data returned by scanning

the QR code and line 5 refers to the summary sheet used to keep track of the running totals for each possible response. See Figure 7 for an example of possible data.

Line 6 looks at a specific range of cells on the summary sheet to find out the final totals for each possible response. Line 7 sets the sheet that will be used to draw the chart.

Lines 9 to 19 form the controlling method that is activated each time a response is received. This method checks for the presence of an existing chart, if no chart is present then a new chart will be generated by making a call to the method createChart(). The code for this method is shown in Figure 6.

```

57 // Local function to create and insert a new chart
58 function createChart_() {
59
60   var chart = sheetActive.newChart() //newColumnChart
61   .setChartType(Charts.ChartType.COLUMN)
62   .addRange(summaryRange)
63   .setOption('title', 'Votes - Last updated ' + new Date().toString())
64   .setOption('legend', {position: 'right'}) // , title: 'Votes'
65   .setOption('legend', {title: 'Votes'})
66   .setOption('hAxis', {title: 'Answers'})
67   .setOption('vAxis', {title: 'Votes'})
68   .setPosition(3, 3, 0, 0)
69   .build();
70   sheetActive.insertChart(chart);
71 }
72

```

Figure 6. createChart() method.

The code in Figure 6 makes use of Google's newChart() builder command to create a new chart to be displayed on the active sheet. The command takes as parameters the type of chart to be built, the data to be used to build the chart and a number of optional parameters used to configure titles, labels, and axes. The last command in the method, line 70, is used to insert the newly created chart in the active sheet.

If the chart is already in existence then a call is made to the method updateData(). This method is used to recalculate the running totals on the summary sheet.

```

21 // check and update the totals
22 function updateData_() {
23
24   var lastRow = sheet.getLastRow();
25   var dataRange = "a2:b" + lastRow;
26   var chartData = dataSheet.getRange(dataRange);
27
28   var iPequi = 0;
29   var iPupunha = 0;
30   var iPineapple = 0;
31   var iPawpaw = 0;
32
33   for (var iRow = 1; iRow < lastRow; ++iRow)
34   {
35     var dataCell = "b" + iRow;
36
37     var dataValue = chartData.getCell(iRow, 2).getValue();
38
39     switch (dataValue)
40     {
41       case 'Pequi': iPequi++;break;
42       case 'Pupunha': iPupunha++;break;
43       case 'Pineapple': iPineapple++;break;
44       case 'Pawpaw': iPawpaw++;break;
45     }
46   }
47
48
49   // update summary table
50   summaryRange.getCell(2, 2).setValue(iPequi);
51   summaryRange.getCell(3, 2).setValue(iPupunha);
52   summaryRange.getCell(4, 2).setValue(iPineapple);
53   summaryRange.getCell(5, 2).setValue(iPawpaw);
54
55 }
56

```

Figure 7. Method for updating summary sheet.

Figure 7 shows the code used to recalculate the summary sheet values. In summary the process involves traversing each row of the data sheet determining the response and updating the running total accordingly.

The number of rows in the data sheet will vary by the number of responses received and as such will be different each time the method is activated. Google script provides a command, getLastRow(), which enables the method to determine the last row in the sheet (Figure 7, line 24). Line 25 shows how the data range can subsequently be built by combining the last row with the string "a2:b". This can then be used to grab the data range for processing (Figure 7, line 26).

Lines 28 to 31 simply set the summary counters to zero to ensure that the totals are correctly determined. Lines 33 to 47 implement a for loop that checks the contents of each cell in the data range and increments the corresponding summary total. Lines 50 to 53 then update the summary sheet with the newly calculated totals.

After the summary sheet has been recalculated the chart must be redrawn to reflect the new data. The code in Figure 8 makes use of the chart modify command to update the chart.

```

73 // Local function to modify an existing chart.
74 function modifyChart_(){
75   chart = chart.modify()
76   .removeRange(summaryRange)
77   .addRange(summaryRange)
78   .setPosition(5, 5, 0, 0)
79   .setOption('title', 'Last updated ' + new Date().toString()) // Update title.
80   .build(); // Must be called to save changes.
81
82   sheetActive.updateChart(chart);
83
84 }

```

Figure 8. modifyChart() Method.

Essentially this method removes the previous data range from the chart before adding the new, updated, data range to the chart. These updates are then built before the Google command, updateChart(chart), is issued to update the existing chart.

D. Process

The students used their smartphones to scan the QR code of their choice, submitting the data request via their phones browser. This, in turn, populated the spreadsheet with the students' choices, activating the script, allowing the results to be observed in near real time.

The QR Code is an encoded representation of the Google URI and data that will be sent to the spreadsheet when student scans it. As can be seen in Figure 9 below, once scanned, the information encoded in the QR code is decrypted and becomes visible to the phone's user. At this point, the participant has the ability to accept or decline the invite to send the data request. When the participant accepts the request to send the data, the next step is to invoke the phone's browser (this can work in different ways, depending on the phone/operating system), which will send the http request to Google for processing. Once processed, a "thank you" message is displayed in the browser indicating the data request has been received.

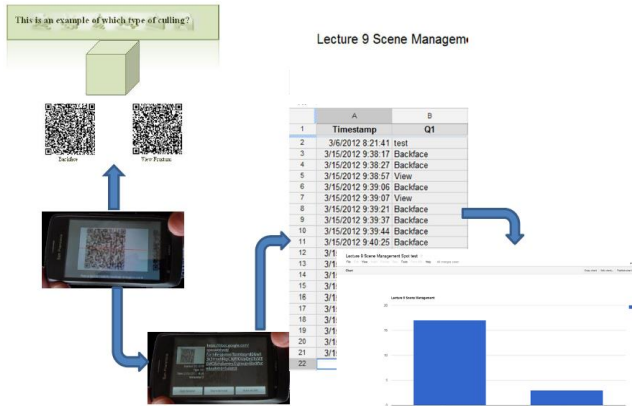


Figure 9. The interactive process

Once the data request has been received, the data is placed in the spreadsheet; the data will be based on the URI encoded in the QR Code. An example is shown below in Figure 10.

It is noticeable from Figure 10 that the spreadsheet date and time stamps the entries as it receives them. The only data that the spreadsheet records is the data encoded in the QR Code and the date and time stamp it generates on receipt of the data. Hence, all entries are anonymous.

	A	B
1	Timestamp	Which one is true?
2	3/22/2012 9:25:08	DAG
3	3/22/2012 9:26:13	DAG
4	3/22/2012 9:26:17	DAG
5	3/22/2012 9:26:20	DAG
6	3/22/2012 9:26:25	DAG
7	3/22/2012 9:26:33	BST
8	3/22/2012 9:27:01	DAG
9	3/22/2012 9:28:00	DAG
10	3/22/2012 9:28:01	DAG
11	3/22/2012 9:29:18	DAG
12	3/22/2012 9:33:01	DAG
13	3/22/2012 9:34:50	Octree
14	3/22/2012 9:35:43	Two
15	3/22/2012 9:35:47	Two
16	3/22/2012 9:35:53	Quadtree
17	3/22/2012 9:37:15	Two
18	3/22/2012 9:42:17	Two

Figure 10. Data sent to the spreadsheet

	A	B
1	Rast	13
2	Geo	6
3	Vertex	0
4	Stencil	12

Figure 11. Summary sheet

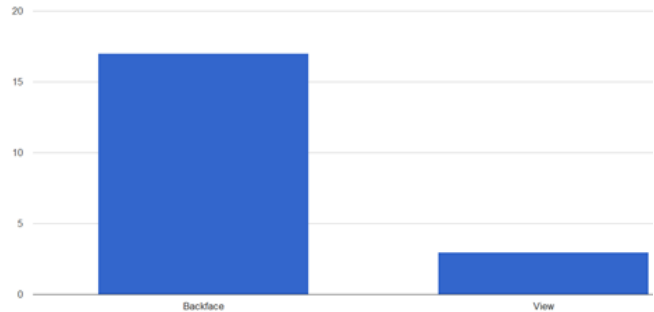


Figure 12. Generated bar chart

As each entry is received, a script is triggered, which counts the entries based on the predefined data set and populates a summary sheet which is used to generate the “near real time” bar charts.

An example of a summary sheet is shown in Figure 11 and an example of the bar chart displayed to the students is shown in Figure 12.

IV. EXPERIENCE

A set of initial tests were developed to examine the viability of the technology and gauge the reaction of the students to the use of this technology within the lecture environment. The aim of the tests was to introduce the interaction concept in a gradual staged manner that would not over burden the student or detract from the lecture.

A. Test Setup

The process used to create this interactive lecture was based on designing a set of suitable questions that could be used to strategically punctuate the lecture to gain maximum benefit for the students [17] [22].

The desired effect was to integrate the technology within the lecture while stimulating interaction with the students [17]. As such, the first set of tests was built to increase in a systematic manner the number of questions within the lecture and the number of QR codes within the questions.

The structure of the first set of tests was designed to build from one question with one QR code in the lecture to four questions with three codes per question in the lecture. Suitable points within the lecture were identified such that the questions could be inserted to maximise their impact. An attempt was made to define suitable points through natural break points within the lecture, e.g., end of a topic, end of the lecture, worked example. Using this principal, questions could be deployed with the aim of giving both the student and the lecturer instant feedback on the comprehension of the material delivered.

B. Participants

Both sets of participants were studying on the Games Software Development Degree. The first group to undertake the interactive lectures was a second year cohort of around 30 students and the second group to undertake the interactive lectures was a final year cohort of around 20 students.

The second year cohort had three consecutive lectures. The first of the three lectures had one question with two QR codes positioned at the end of the Lecture. The second Lecture had three questions, each with two QR codes positioned at appropriate points within the Lecture and the final Lecture had four questions, each with three QR codes again positioned at appropriate points within the Lecture.

The final year cohort had two lectures which were non-consecutive. The first of the two lectures had two questions each with three QR codes positioned at appropriate points within the Lecture and the second Lecture had two questions each with three QR codes positioned at appropriate points within the Lecture.

At the appropriate point in the lecture, the slide would be displayed. To help minimize issues with scanning, article copies of the slide were also distributed. This allowed for the difference within the quality of phone cameras to focus on the projected QR codes. It was fully explained to the students the nature of the experiment and the procedure which should be followed to correctly participate in the experiment.

C. Feedback

Initial feedback from both test groups has been positive and very informative. Feedback ranged from the ease of operation of the process to the size of the QR codes. In general a “buzz” was created within the participant groups generating a positive reaction from the students. This reaction must be tempered by the fact that the students are open to the “Hawthorne effect” [20].

In order to ascertain a clearer picture of the systems use and acceptability with students subsequent testing was planned and undertaken.

It was decided that the most consistent course of action would be to replicate the tests outlined in Section IV B with another Year 2 and Year 4 cohort.

V. ISSUES

Although the overall outcome of the first set of experiments was positive, a number of issues were highlighted that require further polishing prior to the next set of experiments being run.

This section will be divided into two subsections dealing with issues that are prevalent to students and to staff.

A. Issues related to Students

An issue flagged up by the participants centered on the size and positioning of the QR codes as this can have an impact on the accuracy of the scanning process.

The student participants indicated that the size of the QR codes on a projected slide proved difficult to scan directly. Not all students were able to scan it directly. This had been anticipated and article based copies of the slides were issued to counter that problem.

Which tree structure is used for subdividing space in 3D?

- Octree



- Quadtree



Figure 13. Two QR Code Stack

What are Deterministic AI Algorithms?

- A. Behaviours that are determined or reprogrammed.



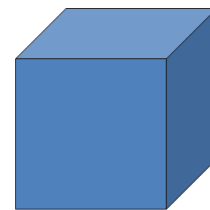
- B. Behaviours that are not determined or not programmed.



- C. Behaviours that are predetermined or preprogrammed.



Figure 14. Three QR Code Stack



This is an example of which type of culling?



Backface



View Frustum

Figure 15. Two QR Codes Side by Side

Strategic AI follows under which category?

A. Character AI. B. Animation AI. C. Group AI.



Figure 16. Three QR Codes Side by Side

Positioning of the QR Codes on the slide raised debate with the participants as some indicated that the barcode scanner software could find it difficult to focus on the required code. Figures 13 to 16 illustrate a number of variations tried out in order to find a balance between size and positioning.

When the question posed had only two available choices there was more leeway to arrange the text and QR codes for both on screen and printed formats. Dealing with two QR codes was relatively straight forward with regard to size and positioning although the student preference was for the stacked vertically display.

Dealing with three QR codes was more problematic as can be seen between the textual difference seen in Figure 14 and Figure 16. Questions that required a more substantial descriptive answer were neigh on impossible to position in a usable manner. The number of QR codes on the slide also influenced the ease of scanning, with three codes per slide proving more challenging for the phone's barcode scanner. This was not insurmountable, but merely added a small time overhead as the participants positioned their camera phone to optimize the scan. Again students opted for the stacked vertically approach.

The overarching problem that affected scanning the QR codes was the quality and abilities of the smartphones camera to focus on the codes.

Camera focusing on the paper based codes generally was satisfactory but a small number of cameras had problems focusing when the QR Codes were small and closely grouped together.

In large lecture theatres none of the students could manage to scan the codes directly from the slides. However, in the small lecture theatres a number of students who had iPhone 5's were able to scan the codes directly. This appeared to be related to the cameras ability to zoom in focusing on a particular area.

B. Issues related to Staff

Time management of both the interactions and the subsequent discussions should be built into the lecture timings allowing for leeway should anything go awry with

the technology. Although the technology is improving it is always worth allowing for small technical glitches and having a cutoff point at which no more tinkering will be done to make the phone scan the QR code.

Some of the issues that have become apparent while trialing the system are not insurmountable but can eat into the time available.

The most common issue faced was the number of students who, on the first exposure to the system, did not have a QR code reader installed on their phone. On the very first run on the system a mistake assumption was made that all student's phone's would have QR code readers and as such time was not allocated for the downloading and configuring of the QR code software on the phones. To a certain degree this can be negate by asking all students to have the relevant software installed on their phones prior to the lecture.

Another technical issue that can cause consternation and affect the resultant graph being displayed is the possibility of multiple scans by the occurring from the same device.

This can be due to the barcode scanner software the students were using. Students should be advised to check the settings of the QR Code software that they are using and where possible set the software to require an acknowledgement or conformation prior to sending the scanned web address.

On one or two occasions during the trial of the system the graph being displayed did not update itself as quickly as might have been expected.

Refreshing the chart manually will help reset the graph but it does have an effect on the desired impact of the interactivity of the lecture.

This approach relies on all the students in the lecture having a smartphone and it is conceivable that a small percentage of the student audience may in fact not have a smartphone or even a mobile phone. The perception would be that this student would be disadvantaged by not being able to take part in the interaction. This would be, of course, true. However, it could be mooted that the student is still engaged in the wider discussion that will come from viewing the generated graph. Another possibility is to rely on the goodwill of a fellow student to share access to their phone.

Currently, the whole process required to create and integrate the QR codes into a lecture are quite cumbersome and may prove challenging for a non-computing subject specialist. Since the first trial run outlined in the original paper [1] the system has been significantly restructured to be more user friendly and have a better user interface. The system now has a menu based approach to allow the lecturer to create the question and answers they would like to use.

Once the question and answers have been created and submitted the automated process creates a Google form, Google spreadsheet and the QR codes.

The Google form will be used to collect the student's submissions via the QR code scanned and the spreadsheet with attached script will process the data to produce the near real time graph.

Thoughts: Interactive Lectures

Questions to elicit your views on the idea of interactive lectures.

In a normal lecture situation when posed with a question from your Lecturer would you be likely to contribute an answer?*
This question is based on a lecture situation that does not involve the use of QR Codes and Smartphones.

1 2 3 4 5

No Definately

In lectures using QR Codes and Smartphones for interaction would you be likely to contribute an answer?*

1 2 3 4 5

No Definately

In the Lectures using QR Codes and Smartphones did you contribute an answer?*

Yes
 No

If you did contribute an answer, what was your reasoning for doing so?*

Figure 17. Survey Section 2

Figure 18 shows the form that is presented to the lecturer to help them build their question. The form collects the question, and answers and when submitted starts the automated process of creating the data repository and QR codes required.

Page 1 of 1

Question creation Form

Form Description

Please enter the question you wish to ask.

How many choices?

	1	2	3	4
Choices	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Choice 1

Choice 2

Figure 17. Form used to collate data required to build Q&A

Figures 3 and 4 help to illustrate how the automated process of creating the QR code is achieved by combining the data in the various cells and using Google's chart API to automatically generate the QR code.

This was not an inconsiderable amount of work to develop but as can be the problem with the reliance on a third party API based system Google has revised their API's

requiring that the system undergo another rewrite to comply with Google's new spreadsheet, forms and graph generation tools. The new version of the system will be developed as a Google web based app. The upside to this is the fact that the user interfaces can be developed using standard HTML5 and CSS, thus more control over the look and feel of the system can be gained.

VI. STUDENT FEEDBACK

The students from each cohort were surveyed to ascertain some form of feedback to gage their thoughts on the system and pedagogical theory underpinning the system.

Selected results from the survey are presented within this section with accompanying thoughts and rational. The survey was split into three main sections; section 1 asking about hardware and software, section 2 asking about views on interactive lectures and section 3 asking for suggestions with regard to improvements to the system.

Figure 17 gives a flavor of the questions asked in section 2 of the survey. This section of the survey was used to try to build a picture of the students thoughts on interactive lectures and how likely they would be to interact with the lecturer under normal circumstances, i.e., answering questions by raising their hand and how likely they would be to answer a question using their smartphone.

The first question asked to the students in this section was "In a normal lecture situation when posed with a question from your Lecturer would you be likely to contribute an answer?". From the research outlined in Section II the expected answer was that few students if any would be tempted to offer an answer.

The chart in Figure 19 shows the result of the answer to the question. The question made use of a Likert scale rather than a straight yes or no to try and gage how adamant the students' answer would be.

Indicated Participation Rates for Normal Lecture Situation

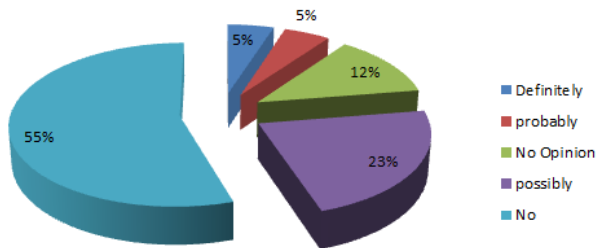


Figure 18. Intention to offer an answer in normal lecture situation

The percentages shown in Figure 19 indicate that the hypothesis expounded in Section II that students are reluctant to answer questions during lectures appears to be justified. Although 55% of respondents indicated that they would defiantly not answer a question the remaining 45% contained an interesting split. The two interesting percentages are the 23% who may possibly contribute an answer and the 12% who seemed ambivalent. It would be interesting to find out what would make the 23% possibles become probables or even definites.

The second question asked to the students in this section was “In lectures using QR Codes and Smartphones for interaction would you be likely to contribute an answer?” From the research outlined in Section II the expected answer was that almost all students would be tempted to contribute an answer.

The chart in Figure 20 shows the result of the answer to the question. Again the question made use of a Likert scale rather than a straight yes or no to try and gage how adamant the students' answer would be.

As can be seen from the results almost 90% of the students surveyed indicated that they would offer an answer. This was close to what was expected based on the research undertake for Section II. Interesting to note the 8% of respondents who had no opinion; further work will be required to ascertain why students opt for “no opinion”.

The third question asked to the students in this section was “In the Lectures using QR Codes and Smartphones did you contribute an answer?” This question, on the surface, may seem a strange question to ask but it was an attempt to try to judge the accuracy of the scanned QR code data from the actual lectures.

Indicated Participation Rates for Interactive Lecture

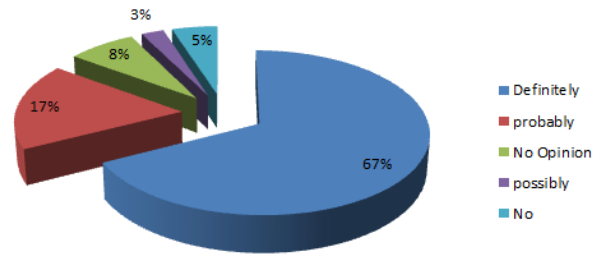


Figure 19. Suggested participation rates for interactive lectures using QR codes and Smartphones

Actual Participation Rates for Interactive Lecture

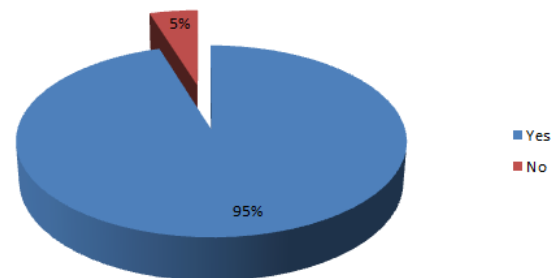


Figure 20. Participation rates for Interactive Lectures

Thankfully, the result to this question was an almost perfect match to the actual data gathered from the interactive lectures and had been the expect result.

Again, reflecting on the literature reviewed for Section II the author's interested was piqued as to why 95% of respondents felt that using the QR code system they would offer an answer. The obvious candidate was anonymity as cited by [14].

The fourth question asked to the students in this section was “If you did contribute an answer, what was your reasoning for doing so?” This question required the respondent to give a text based short answer. This was preferred to using any list based technique in order not to elude to answer of anonymity.

Anonymity influenced decision to scan and submit an answer.

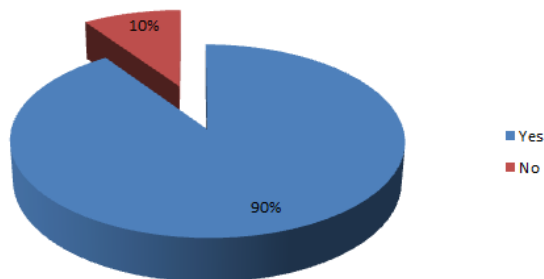


Figure 21. Anonymity plays a part on interaction

After sifting through and collating the responses to this question it became clear that hypothesis of anonymity was indeed a realistic prospect. Further questioning to gain a deeper insight into the students' thought process will be required in order to better understand the pedagogical issues underlying student contribution during lectures.

This section of the questionnaire more or less fitted with the ideas postulated in Section II, however, some of the results were not as clear cut as expected.

In the final section of the questionnaire, suggestions for improvements were sought to enhance the system and processes involved with using the system. One recurring improvement was to have more varied charts for displaying the results. This indicates that the students were paying a level of attention to the results more than superficial. It would be interesting to discover what the students think they can elicit from displaying the results as different charts and which chart types they would like to see and why.

VII. CONCLUSION AND FUTURE WORK

Overall, the interactive lectures trialed with various cohorts have been generally well received by the students and the staff contributing to positive interaction between the lecturer and the students.

Students appeared to enjoy the break in the lecture and the feedback and discussion generated by the visual charting of their responses. It also created a focus point for the students to reflect on their understanding of the material taught and to apply that understanding. By the same token, it proved to be beneficial to the lecturer indicating the level of understanding of the delivered material to the students.

The anonymity of the whole process was cited by a number of students as positive and this has been borne out by the survey. The students gave the impression that they were comfortable with the fact that they could answer the questions freely, getting them wrong and not feeling awkward in front of their peers.

With regard to performance, this prototype system works well, producing the column chart of responses in near real time. Chart production will be expanded in line with

suggestions made in the student survey to include line, pie and scatter charts. Advantages this system offers is the fact it is free, flexible, easily tailored to suit the lecturer's needs and platform independent.

A further avenue for investigation will be the correct utilization and positioning of the interactive lectures within the overall module lecture delivery schedule. Over or under use will have an impact on their effectiveness.

Further investigation will be made with regard to the sizing, positioning and visibility of QR Codes from projected and paper based slides. The rapidly changing hardware of smartphones and ever improving cameras suggests that the current inability of the majority of phones to scan a QR code from a projected slide may be at a demise within a couple of phone generations.

The use of the technique within the tutorial/seminar setting to encourage more debate on theoretical and social subjects is path that will be followed.

Further investigation will be undertaken into the relative pros and cons of storing complex responses in the spreadsheet, as evidenced in Figure 10, and simplistic responses in the form A, B, C, etc. The outcome of this investigation will have an impact on the future development of the software.

A significant proportion of future work will be involved in redeveloping the system to utilize HTML5 and CSS for the user interface to the software to allow cross discipline use. The script code will continue to be hidden from the user allowing them to concentrate on the development of their question bank and will be revised to comply with Google's criteria for use.

The project is ongoing and the positive feedback received from the students indicates that it is a worthwhile pursuit for both the lecturer and the students.

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