Gauging Students' Understanding through Interactive Lectures.

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Abstract. The Personal Response System (PRS) enables audience responses to multiple choice questions to be collected quickly, and for a summary of all the answers to be displayed to the whole group immediately, making it a useful tool for promoting classroom discussion. This paper describes its use as a means for assessing students' understanding of previously learned material, in the context of two consecutive database modules. The PRS was used in the areas of Entity-Relationship diagrams, Relational Algebra, and SQL, and proved to be useful in assessing students' current level of understanding.

1 Introduction

It is often difficult for a lecturer to know the extent of students' knowledge outside of formal summative assessment, particularly if prerequisite material is presented in a different module taught by another lecturer. The aim of this paper is to describe our use of the Personal Response System for eliciting timely feedback from students in two large database classes.

1.1 The Personal Response System (PRS)

The PRS allows for responses to multiple choice questions to be submitted by each person in a large group, and then present the responses as a bar chart immediately after all responses are collected. Each student has a handset (with buttons 0 to 9) with which to indicate their answer (Fig. 1).

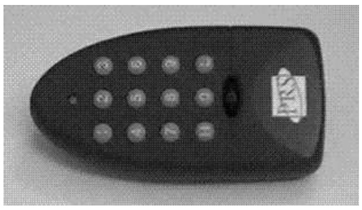

Fig. 1. A PRS Handset.

2 Context

Computing Science students at the University of Glasgow are taught Database material in first, second and third year, typically by different lecturers. In the first year, they have three weeks of database material (data modeling, relations, Access, simple SQL) within a general Computer Systems module. In the second year Information Management module they have five weeks of database material (relational algebra, query optimization, normalization, transaction processing). The third year is the first time the students have a module entirely devoted to Databases (advanced SQL, integration with applications, implementation).

2.1 Not-knowing

While this arrangement ensures that database material is a continual thread through the students' studies, there are two main problems:

- As the lecturers are different, the second and third year lecturers do not necessarily know the extent to which the topics in the previous years have been covered and understood. They can look at the defined curriculum, lecture notes and assessed exercises, but they will not necessarily know the extent of understanding of the relevant material. The problem is further complicated by the fact that the focus of the second year Information Management module is different to that of the more advanced third year Database module.
- Students easily forget material from one year to the other. They often do not recognize the extent of what they have forgotten, and resent having revision lectures at the start of the year. In particular, while recalling overall concepts (e.g. entities and relations), they tend to have forgotten finer details (e.g. cardinality and participation). This is further complicated by the fact that not all students continue from first to second year Computing Science and from second to third year Computing Science, so their focus tends to be on the immediate assessment, not on what might be required in future. The forgotten details are crucial for understanding the more advanced material in subsequent years.

Outside of summative assessment, lecturers only know the extent of students' understanding through small group tutorials and labs (typically only part of the class), and through informal interaction with individual students. It is hard to get a big picture view of the overall extent of understanding within the class. Students too have to rely on summative assessment and infrequent interactions with the lecturer to check their understanding is complete and correct.

2.2 Not-understanding

The other problem we have found with database teaching is the students' difficulty with relational algebra, and its connection to SQL. Students are introduced to this in second year, and they need a firm and secure understanding for the more advanced material covered in third year. Their performance in second year examples classes and examinations in 2002/3 revealed that they struggled with understanding the theoretical concepts, and that they start third year knowing some SQL syntax, but have little knowledge of its theoretical basis.

3 Addressing the problems: PRS

We wished to increase the interaction between lecturers and students in large classes, with the aim of:

- increasing the lecturer's knowledge of students' understanding;
- increasing the students' knowledge of their own understanding;
- increasing the students' knowledge of lecturer's expectations;
- increasing the students' understanding of difficult material.

Laurillard[4] emphasises the importance of frequent communication between students and lecturers. Various methods of holding interactive lectures have been shown to enhance student understanding within mechanics courses [3]. Non technical solutions to the problem of communication between a large group of students and the lecturer include simple voting by hands, volunteered verbal answers, written tests, small group discussions, and Flashcards (students hold up a coloured piece of card, the colour representing their answer [5]).

These methods tend not to be anonymous, favour the confident student, and do not enable the immediate calculation of quantitative data that enables students to see their standing amongst their peers. Written tests are costly and time consuming, and, if they are not summative, are seldom taken seriously by students.

Benefits of using the PRS system include:

- less costly than a written test;
- students can see how they stand in relation to their peers;
- students get immediate feedback on a problem that is fresh in their mind;
- stimulates discussion about student misconceptions;
- easier to get representative, quantitative data than simple hands-up' voting;
- students know the extent of understanding required of them, at a particular time in the module;
- encourages lecturer-student interaction, even within large classes.

We chose to use PRS three times in database lectures: for ER diagrams, for SQL queries, and for Relational Algebra (RA) expressions.

For our particular goals, PRS allowed us to:

- reinforce material covered in the previous year;
- reassure students about what they do remember from the previous year;
- reveal students' misunderstandings of material covered in the previous year, including highlighting material they may be feeling complacent about.

The PRS system has successfully been used elsewhere (statistics [7], mechanics [1]). The main educational advantages stated for the use of PRS are to enhance the feedback from learners to teachers, allowing for the lecturer to better prepare subsequent material, and for the initiation of class discussion [2]. PRS has been used to reinforce or redeliver recently presented material, focusing on revealed misunderstandings [7], and at the end of a module to assist students in preparing for examinations.

4 Method: using PRS for learning Database material

Our use of PRS for ER diagrams and for SQL queries was aimed at assisting the lecturer in establishing how much the students' remembered from the previous year. The Relational Algebra (RA) PRS exercise aimed to reinforce material students typically found difficult.

4.1 Not-knowing

The ER and SQL PRS exercises were held at the start of the term in both the second and third year modules. In both cases, the aim was for the lecturer to find out the extent of the students' knowledge of the previous years' material, and for the students to find out the extent of what they were expected to know.

In second year, the exercise entailed giving students a textual description of a domain (in this case, the information stored by a video shop), and each question presented four possible ER diagrams for representing information within the domain. The students needed to indicate which one of the ER diagrams was correct (Figs. 2 & 3). The students had studied ER diagrams in first year.

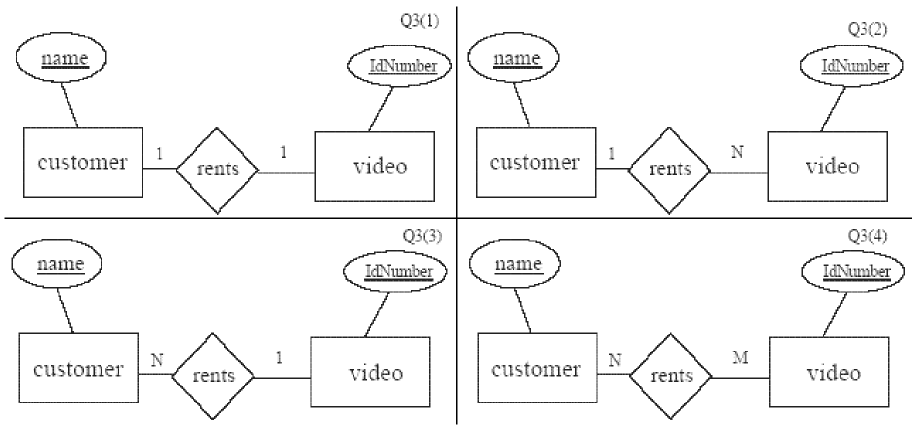

Fig. 2. A question from the Entity-Relationship exercise.

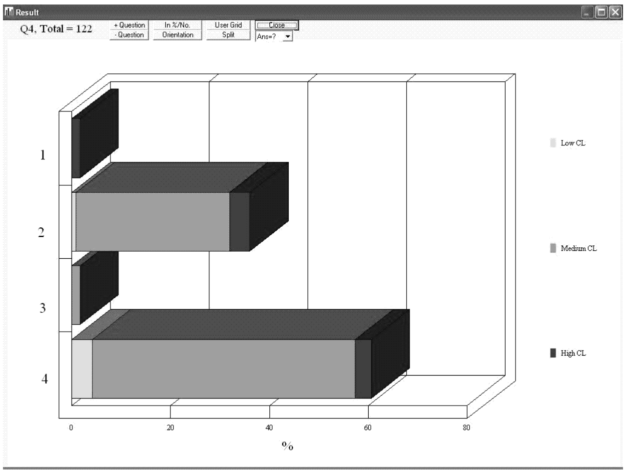

Fig. 3. The display of responses for the Entity-Relationship question in Fig. 2.

In third year, the exercise entailed giving the students two SQL queries (A and B), and asking them to indicate whether the answers to these queries were identical, the answer to A contained within B, the answer to B contained within A, or different (Fig. 4). The students had studied SQL extensively, and its relation to relational algebra in second year.

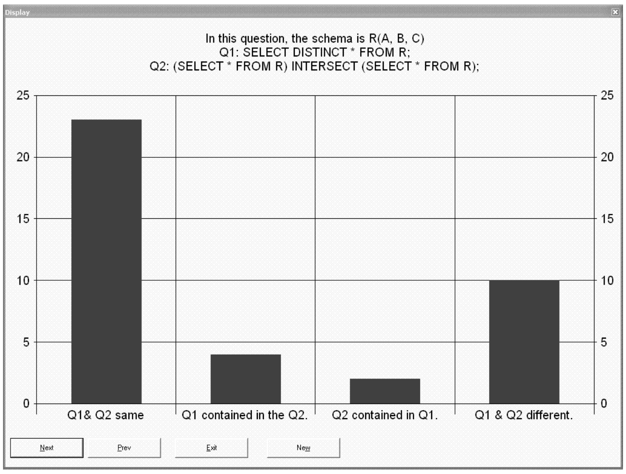

Fig. 4. A Question from the SQL exercise, together with its responses.

4.2 Not-understanding

The RA PRS exercise was held in week three, after the lectures in which relational algebra and its relation to SQL were presented. The aim was to:

- demonstrate to the students the extent of the understanding required;
- demonstrate practical application of the concepts presented;
- reinforce material that students typically find difficult.

Students were presented with an SQL query, and four RA expressions: they needed to indicate which of the expressions matched the query (Figs. 5 & 6). In some cases, more than one answer was correct, thus allowing for discussion of expression equivalence.

SELECT * FROM person, animal
WHERE person.houseNum = animal.houseNum

1. $person \bowtie_{(person.houseNum=animal.houseNum)} animal$
2. $\sigma_{(person.houseNum=animal.houseNum)} person \times animal$
3. $\prod_{(houseNum=houseNum)} person, animal$
4. $\prod_{(houseNum=houseNum)} person \bowtie animal$
5. Don't Know

Fig. 5. A question from the Relational Algebra exercise.

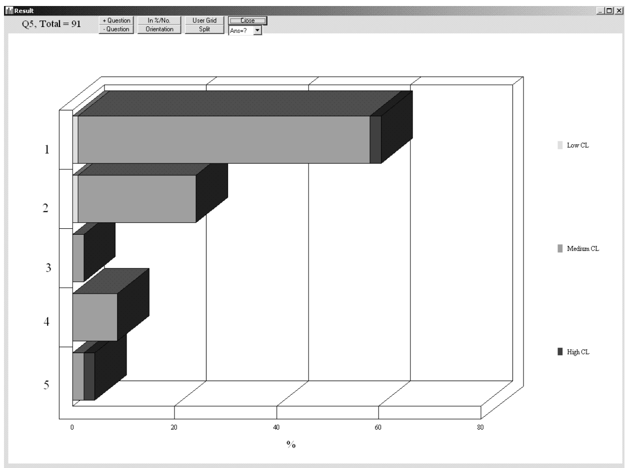

Fig. 6. The display of responses for the Relational Algebra question in Fig. 5.

5 Practical details

The PRS hardware consists of a set of infrared handsets (Fig. 1) and receivers (Fig. 7), connected to a computer that has its screen displayed to the audience(Fig. 8), usually through a data projector. The handsets have 10 number buttons and 2 'confidence' buttons. A student can use these extra two buttons to modify their response to show either higher or lower confidence in their answer (The handset defaults to 'normal confidence'). This is then shown on the bar chart (for example, as can be seen in Fig. 3).

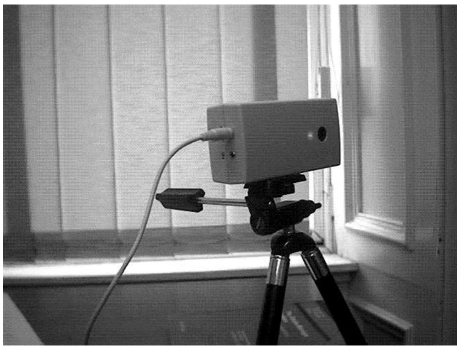

Fig. 7. A PRS Receiver.

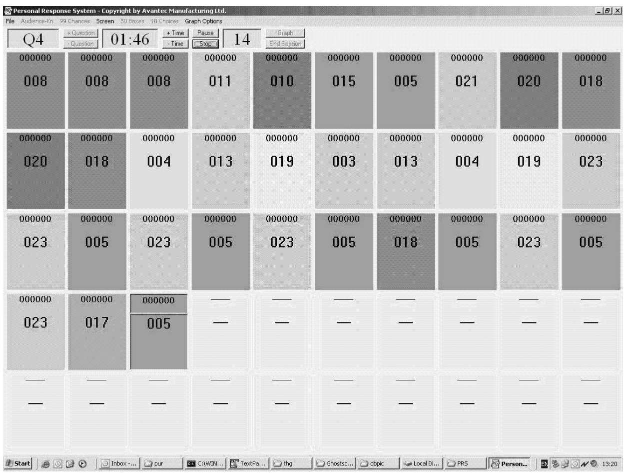

Fig. 8. Screen display while the students are registering their answers.

5.1 Considerations for use

Time to vote When a button on the handset is pressed, this is transmitted to the computer, but the signal may be lost (it may be blocked by other signals or not in line of sight of a receiver). Since the registering of a vote is not guaranteed, the unique ID for each handset that registers a response is displayed to the whole audience (the IDs on the screen are colour coded by the last digit of the ID to ease identification). Any student who sees that their response has not been successfully received must revote. Students quickly become adept at voting and revoting, and by the end of their first session 100 students' responses can be collected in less than a minute.

Time to set up The equipment (receivers and computer) requires less than 5 minutes to setup. This is usually done as the class are coming into the lecture theatre.

Cost If the handsets are bought in bulk the price can be reduced to about £20 per handset; the receivers cost approximately £150 each. The recommended ratio of handsets to receivers is 50 to one. While the cost of handsets and receivers for one class may be prohibitive, sharing this cost over several departments throughout the university makes the purchase justifiable.

Handset Distribution Since the equipment is used by many classes the handsets are distributed to students during each lecture. The simplest distribution method is to give each student a random handset as they walk in the door. This means that any data collected across more than one lecture cannot later be aggregated by student.

Other Equipment The reliance on the data projector to display the computer screen is not ideal as technical failures are possible though infrequent. The receiver equipment requires that the computer have a serial port. Modern laptops only have USB ports, and not all serial to USB adapters work completely reliably.

6 Results

6.1 Learning outcomes

The first, simpler ER diagrams questions were answered well by the second year students; there were more problems with the later, more difficult questions. The exercise was successful in highlighting to the students the deficiencies in their knowledge (e.g. weak entities, participation, cardinality). This was particularly important as previous experience indicated that students felt complacent about ER diagrams at the start of second year, having learnt them in first year. This PRS exercise has run for both years that this second year module has run, so no learning comparisons can be made; however, the lecturer reports that the majority of students are very careful about the production of their ER diagrams, even for unassessed problems.

The easier SQL questions were answered well by the third year students, and, like the second years, the performance deteriorated with the more difficult later questions. The exercise was considered very useful for the lecturer in determining the extent of what had been covered in theoretical aspects of SQL in second year. It was also a clear indicator to the students of the extent of knowledge that may be expected of them in their summative assessment. The lecturer reports that the performance of the students is higher than previous years, and (independently of the second year lecturer) reports that students are more careful in their use of SQL.

As the RA exercise covered material that had been recently presented in the second year class, the pattern of responses was different: the first, easier, questions were poorly answered, and the lecturer discussed and explained the correct answers to these questions. The students' performance on the later, more difficult, questions was better, indicating that the students were correcting their misunderstandings, and applying their new knowledge immediately. The lecturer reports that their understanding of relational algebra is markedly improved when compared with students last year (who did not have this PRS exercise, and who had learned some relational algebra in first year).

As the aim of the ER and SQL exercises was primarily to reveal the students' knowledge of material that they had covered in the previous year (to both the students and the lecturers), the responses to these questions did not influence the subsequent delivery of material. As the RA exercise was used to determine students' understanding of recently presented material, the students' responses indicated to the lecturer which aspects of RA needed further immediate explanation.

6.2 Student responses

Students' responses to the use of the PRS are generally positive: they see the benefits of the exercise in consolidating their understanding, in identifying where their knowledge deficiencies are and where they need to revise or catch up material, and in assisting them in their preparation for summative assessment. Students report that they are more likely to attempt to answer the question using PRS than if the lecturer requests a volunteered response by a hands-up' or verbal method.

7 Conclusions

Using PRS to support large class teaching is clearly effective for both students and lecturers in assisting students in achieving the level of understanding of recently taught material required for summative assessment. Our approach is to use PRS in a timely manner, concentrating on informing both the lecturer and student of current knowledge status at an important point during the semester.

By integrating our use of PRS within the Database materials covered in different year levels, we hope to enhance the students' understanding, address the problems of student complacency, and assist the lecturers in providing continuity in the database curriculum.

8 Acknowledgements

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