

DYNAMIC CAA AND PEER SUPPORTED LEARNING IN INTERACTIVE CLASSROOMS

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Abstract

Advances in interactive classroom technology are opening up exciting, new ways of engaging students with CAA during face-to-face teaching. Project LOLA (Live and On-Line Assessment) is a 3-year national teaching fellowship project started in 2001, which has been exploring how one-way group response systems and two-way classroom communication systems can be used most effectively. The PRS (Personal Response System) is a popular group response system used as a means of promoting greater interactivity in the classroom, but there are many limitations in its standard use. These limitations are addressed in this paper and a system called RxShow, which overcomes some of them described. A significant benefit of RxShow is its integrated delivery with the option for dynamic display of results, which encourages “peer supported learning”. Assessment of students by the lecturer and feedback to the lecturer from students become more lively and interesting. Results from student evaluations of the improved approach are extremely positive.

Project LOLA

There are numerous drawbacks to traditional lectures, as references generated by the entry of “attention span” and “lectures” into a Web search engine will testify. Fifteen minutes is a common time interval quoted for student attention. Technology, especially the overuse of Powerpoint, is accused of making lectures even worse: “Power corrupts. Powerpoint corrupts absolutely.” (Tufte, 2003). Yet technology both creates and solves problems. Interactive classrooms can provide technology in support of good pedagogy. This paper describes how the “evil of Powerpoint” can be exorcised by making it more interactive and responsive to an audience.

Project LOLA (Live and On-Line Assessment) is a 3-year national teaching fellowship project started in 2001, which has been investigating how one-way group response systems and two-way classroom communication systems can

be used most effectively. Its aims are to develop, apply and evaluate interactive assessment technology, specifically:

- to establish a set of practical techniques for using interactive classrooms in face-to-face teaching
- to identify guidelines for best practice in the delivery of live, formative assessment
- to develop an integrated model for teaching, learning and assessment in an interactive classroom
- to evaluate the effectiveness of interactive classrooms for student learning

Classification of Interactive Classrooms

An interactive classroom may be defined as CAA technology used to help a lecturer communicate with students during face-to-face teaching. Students become more actively engaged in classroom activities by answering questions with immediate, live feedback from both computer and lecturer. A group or audience response system allows one-way communication from student handsets to a lecturer's computer; a classroom communication system allows two-way communication between student and lecturer computers (Figure 1).

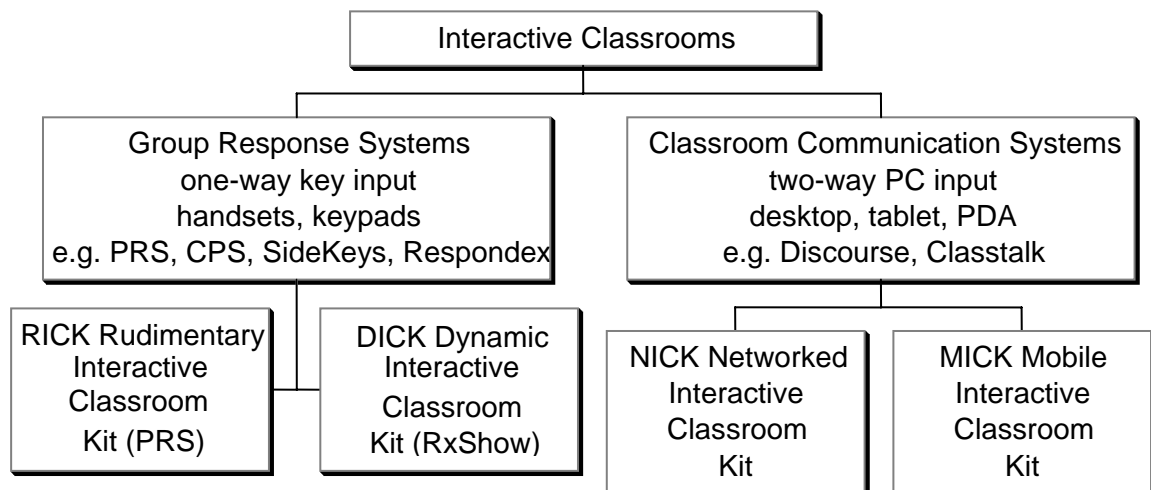


Figure 1. A Classification Scheme for Interactive Classrooms



Figure 2. Group Response System (top left–students; top right–lecturer) vs. Classroom Communication System (lower left–networked; lower right–mobile)

The benefits of basic group response systems are well recognised (Horowitz, 2003). The Interactive Lectures Interest Group web site <http://www.psy.gla.ac.uk/~steve/ilig/> provides guidance on handset use. McCabe and Lucas (2003) focuses on the pedagogical benefits of using a classroom communication system, which is more powerful than a group response system, but trickier to use (Figure 2). This paper focuses on the pedagogical benefits arising from recent improvements in group response system software.

Static Group Response Systems

Group response system with handsets, such as PRS (McCabe, Heal and White 2001) can be used for many different purposes:

- to break up delivery of content during lectures
- to encourage revision prior to an exam
- to evaluate a course unit
- to poll student understanding or interest
- to gather personal data or subjective views

In regular teaching, Peer Supported Learning¹ (Crouch and Mazur, 2001) is a well-recognised technique for delivering objective questions, especially when the aim is to promote understanding of an underlying concept. Typical stages are:

¹ This is my preferred terminology for what is known as 'peer instruction' in the US

1 *Development and selection of question*

A lecturer provides background information or guidance to help in solving a problem. The restriction of PRS to multiple choice or simple numeric questions is taken into account, especially when objective questions from other CAA software with a wider range of question types, e.g. QM Perception, are used.

2 *Question delivery*

The method of presenting PRS questions depends upon their complexity.

Simple questions can be asked verbally and plain text questions can be presented within the software (Figure 3 left). Questions with diagrams, pictures and mathematical symbols normally require a separate display using OHP, Powerpoint presentation or even interactive whiteboard. Preparation of classes often needs to take room facilities into account. Some teaching rooms have PRS permanently installed, some have PC projection onto two adjacent screens, while others require portable equipment to be booked in advance.

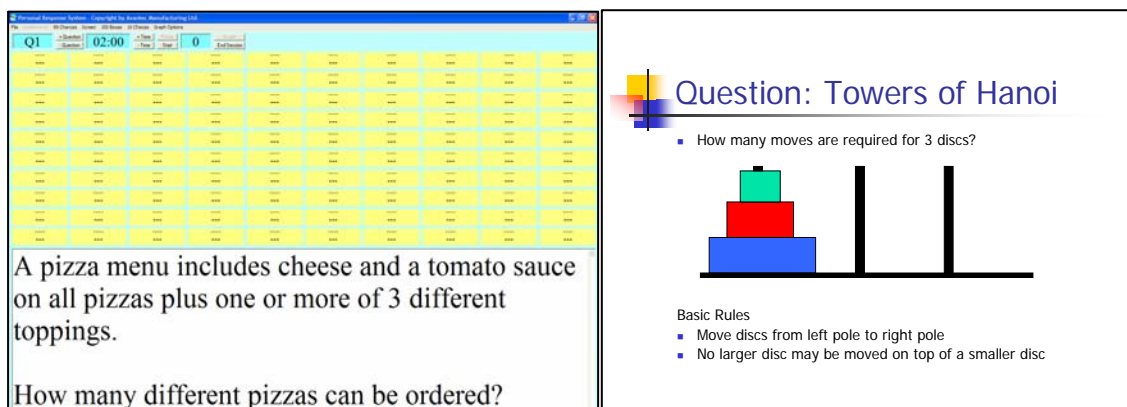


Figure 3. Integrated (left) and Separate (right) PRS Question Presentation

3 *Individual or group work*

Group discussion is an essential feature of peer supported learning, but may or may not be appropriate at this early stage. It is more common to begin with individual work before asking students to discuss their answers at a later stage.

4 *Collection of answers*

This stage can be the most time-consuming, but has limited pedagogical benefit apart from peer-to-peer comparison of times taken to answer questions. Status boxes (Figure 3 left) are filled on the PRS screen in the sequence that answers are received, so the competition to answer first can be a motivating factor. Unfortunately, the variability in the location of the status box feedback for each question can make it awkward for a student to confirm

that their answer has been received by the system. The failure of a PRS receiver to pick up a handset response if it is already busy exacerbates this problem.

5 *Display of results (divergence)*

Both students and lecturer now see the distribution of answers in the form of a histogram. In standard PRS there is no indication of the correct answer to an objective question and the histogram is static, i.e. it does not respond to subsequent input from handsets. The lecturer could close the question by discussing the correct answer and commenting on the class results at this stage.

6 *Class discussion with optional iteration of stages 4 and 5*

In the common event of divergent answers, students can be given another chance to answer the question. It is the group equivalent of a “Who Wants to be a Millionaire?” contestant answering after “asking the audience”. The benefit is that students have an opportunity to learn from each other and from their own mistakes. A simple approach is to allow a second or further attempt at answering the question in the light of the group results only.

Peer Supported Learning encourages small group discussion of the problem and allows individuals to persuade others that their solution is correct. Without discussion it can be argued that students will automatically choose the modal answer of the group, avoiding the need for any reasoning. Yet apart from the difficulty in preventing students from discussing their answers, it is interesting that students themselves are unhappy about unthinkingly following the crowd and naturally seek a reason for changing their response. This natural process can therefore be formalised by iterating stages 4, 5 and 6: discuss – collect answers – display results.

The main drawback of this approach, which makes it controversial, is the time taken up by the discussion (pedagogy) and the repeated input of answers (technology). While lecturers and students do not object to the use of learning technology in the classroom if it is readily available and easy-to-use, they do object if there is perceived waste of “content delivery time” caused either by the technology or the pedagogy. Because PRS displays static results, the pedagogy and technology run in series, i.e. discussion and display of results do not occur simultaneously. This paper considers how dynamic display of results allows pedagogy and technology to work more effectively in parallel.

7 *Closure (convergence)*

The ideal conclusion to an objective question would be for every student to select the correct answer, i.e. achieve “perfect convergence”. Even in this situation, there is no guarantee that all students understand how to solve a problem or reason correctly. Follow-up PRS questioning or use of a classroom communication system could deal with this. In practice, a lecturer would probably conclude the discussion by giving a quick explanation or reviewing the question before moving on.

When convergence is not achieved, the situation is less clear. The lecturer needs to make a decision about how many times to iterate, according to how results are changing, whether further guidance is needed and, possibly most significantly, how long the whole process is taking. In practice, it is rare for a question to be repeated more than two or three times, before it is brought to a conclusion.

General benefits and drawbacks of using PRS are given in McCabe and Lucas (1993). More specific factors, which limit its effectiveness as a pedagogical tool are identified as follows:

- The integration of screen information is weak, only allowing simple text questions and status boxes to be displayed together. Some information, such as menu items, is unnecessary for students to see at all. The display of questions, status boxes, results, correct answers and feedback on a single screen is often necessary, but tricky.
- Operation is non-trivial, especially for novice users. In front of a live class, even the simplest of software can become a distraction and unnecessarily takes the mind of the lecturer away from the class. If PRS is used on one screen and separate software on another, the need for dual operation makes matters worse. Figure 2 shows how the lecturer is focused on the laptop screen and is unable to maintain eye contact with the class. While an additional screen at the back of the room might help, simplified delivery is better.
- Status boxes are filled sequentially according to input time rather than handset number, making it hard for students in large classes to identify whether their responses have been accepted and giving no information about invalid selections. Furthermore, it is difficult for the lecturer to see what proportion of the class have responded.
- Static results are displayed, i.e. further handset input is not accepted when a frequency histogram is on the screen. When there are second and further attempts at the same question, flipping between the results for comparison is clumsy and distracting for the lecturer.
- Results can only be presented as a histogram and the correct/incorrect answers to an objective question cannot be shown automatically on the bars.
- Question solutions, explanations, feedback or hints cannot be displayed automatically.
- Lastly, if a lecturer is delivering content and wishes to gather subjective feedback on student perceptions, e.g. their level of understanding, the PRS mechanism is necessarily disjointed and disruptive to the flow of the lecture.

Dynamic Group Response Systems

A dynamic group response system, using PRS hardware (handsets and receivers) with RxShow software², provides both technical and pedagogical improvements to a static group response system using basic PRS software. Most of the drawbacks identified in the previous section are eliminated by the use of this Dynamic Interactive Classroom Kit (DICK). The benefits are:

- PRS delivery integrated seamlessly within Powerpoint presentations, smoothing transitions between content and question delivery and eliminating the need for twin projection screens for questions, which include mathematical equations, diagrams or pictures.
- Considerably simplified operation using the same key or mouse button to progress through all the stages of Peer Supported Learning. This simplification has allowed traditional Powerpoint lecturers, to exploit the pedagogical benefits of interactive lectures immediately.
- Status boxes for each student are at a fixed position on the screen allowing for easier identification of input by students, especially if the screen positions correspond to the room layout itself. The proportion of the class who have responded is seen clearly by the lecturer.
- An indication of whether input is valid, e.g. 5 entered in 4-choice MCQ shown as a red rather than green status box.
- Flexible display of results, e.g. as pie diagram instead of histogram
- Dynamic display of results whereby any changes to responses are displayed immediately on the chart
- Automatic visual display of correct choices on charts, solutions, feedback or hints
- Dynamic student feedback allowing students to respond to background questions during content delivery, e.g. how well do you understand this?

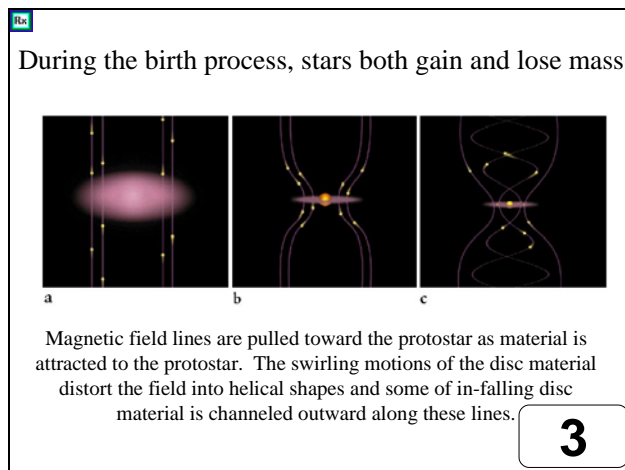
Dynamic Peer Supported Learning (PSL) is a teaching method, which exploits these improvements. There are many variants, but typical use is as follows:

1 Development and selection of questions

Since questions are embedded as slides in Powerpoint presentations, existing traditional slides can be used or upgraded to interactive versions. At this stage it may be necessary to ascertain whether students have sufficient background knowledge or understanding to answer questions. Weekly interactive lectures have been used throughout the year on two elective astronomy units. Students are expected to read a chapter of their set book before attending the class and they are polled on their understanding of the content. In order to make this more explicit, they are given a set of questions and asked to respond via their handsets according to how readily they think they could answer the questions (0 = extremely poorly 9 = extremely well). The average

² RxShow can also be used with other group response systems, infra-red, radio or wired

numerical value displayed on-screen is used as a subjective indicator of how much help will be needed during the class. Discreet feedback boxes are included regularly on content slides (Figure 4), so that students can register any parameter that the lecturer wishes to record, e.g. understanding, difficulty, attention, relevance, familiarity, pace. A lecturer can continue speaking, while students register their dynamic feedback instantaneously in the background.



Feedback Box

Figure 4. Dynamic Student Feedback

2 Question delivery

A typical objective question slide is shown in Figure 5. Only the question and status boxes are displayed initially.

3 Individual or Group Work and Initial Responses (divergence)

Students usually consider their initial responses individually. Feedback on handset input is displayed at a fixed screen location for each student: green/red for valid/invalid responses respectively. The lecturer can wait until a sufficient proportion of valid responses have been received, before pressing a key to reveal the initial results, or allow a fixed time for answering. The results chart is now displayed with the initial responses. Histogram bars are all shown in the same colour, so that the correct answer to an objective question is not revealed at this stage.

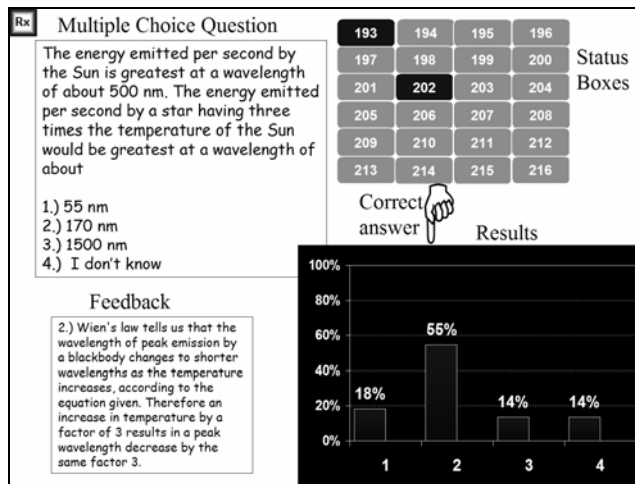


Figure 5. Final Screen after Dynamic Questioning

4 *Dynamic PSL (Collection of answers - Display of results - Class discussion)*

This is the interesting stage of Peer Supported Learning, which combines together the iterative stages 4, 5 and 6 of the static method. Students can now change their answers and observe an animated results chart responding instantaneously to their input. They can discuss the question/responses with their neighbours even while the results are changing, since some students can be discussing while other are responding. The effect of additional guidance from the lecturer can be seen immediately. Above all, it becomes easy for the lecturer to see whether the results distribution is converging (Figure 6), diverging, oscillating or exhibiting chaotic behaviour and decide when to move on to the final stage.

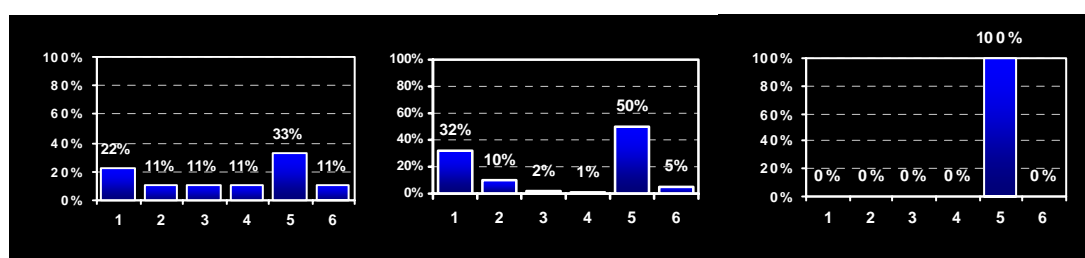


Figure 6. Perfect Class Convergence towards a Correct Answer!

5 *Closure (convergence)*

The final stage of questioning is initiated by pressing the same single key or mouse button. The results chart no longer responds to student handsets, the bar for the correct answer is displayed in green with incorrect answers in red, an additional marker confirms the answer (for colour blind males!) and

feedback or a solution is displayed. The lecturer is free to add further comments or advice before moving on.

The Powerpoint presentation can now proceed smoothly with plain content slides, dynamic student feedback slides or further interactive questions. Slide progression and slide builds are all controlled by a single key or mouse button, so that the lecturer can concentrate on engaging with students rather than computer operation. At the end of each astronomy lecture dynamic student feedback is collected on the same set of questions that were asked at the beginning of the class. Although only a crude, subjective measure, comparison of the figures immediately reveals whether students have found the lecture useful.

The results displayed during an interactive presentation can be saved either in a plain text file or as a separate PPT presentation. The latter provides a convenient way of reviewing class responses at a later stage or making them available to students.

Volunteers and Conscripts

Volunteering and conscription provide two alternative ways of using the computer to assist in asking questions. The former displays the handset numbers of students with the “fastest fingers” registering their wish to answer (Figure 7). The latter displays handset numbers of student(s) selected to answer a question individually. In each case, the questions are answered verbally. Volunteering encourages competition on easier questions and promotes the involvement of stronger students; conscription enforces response on harder questions and promotes the involvement of weaker students. Used sparingly, both add interest and variety during interactive classes.

The best place to search for stars that are in the process of forming is?

1. between interstellar clouds, where the density is low enough not to block our view of the star-forming region.
2. inside large, hot regions of ionised hydrogen gas (H II regions).
3. in cold regions inside interstellar clouds.
4. I don't know

Fastest Fingers

193	194	195	196
197	198	199	200
201	202	203	204
205	206	207	208
209	210	211	212
213	214	215	216

Volunteer Status Boxes

Keypad #199 Volunteer 1

Keypad #195 Volunteer 2

Figure 7. A Volunteer Question with Two Students Selected

Evaluation

Student evaluation has been collected by adding extra slides with static questioning at the end of some lectures. Figure 8 shows typical responses obtained from 150 students in a sports science lecture, who had previous lectures delivered using non-interactive Powerpoint slides. The lecturer had no previous experience of delivering interactive presentations and the students had never used handsets before. The simplicity of the system allowed the lecture to be delivered without any technical knowledge.

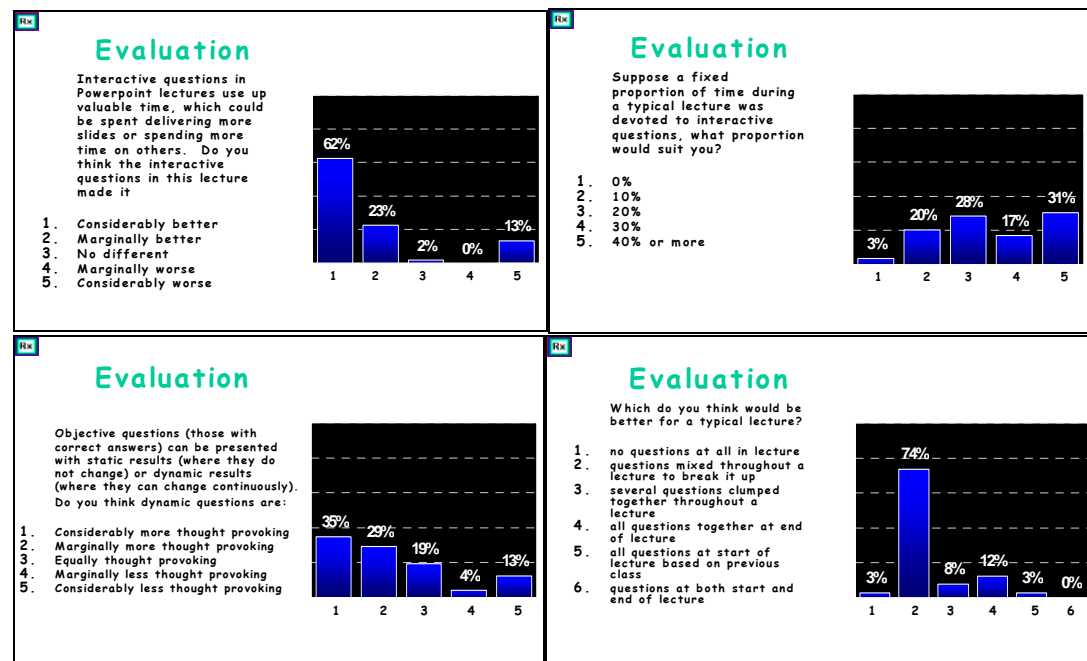


Figure 8. Student Evaluation of Dynamic CAA

Similar student evaluation was collected from the smaller astronomy class, which used interactive questioning every week. General conclusions are that:

- lectures are considerably improved, despite the extra time used up by the questioning
- the proportion of time which students thought should be spent on questions (Figure 8) was comparable to or greater than the proportion of time actually spent (~25%)³. Almost a third of all students suggested that lectures spend more than 40% of the time on interactive questions. It was the lecturers who were more concerned about the loss of time available for content delivery
- dynamic questions were more thought provoking than static questions
- and, interestingly, the vast majority of students expressed a strong preference for questions interspersed throughout lectures to break them up.

³ Accurate timings were made during ~25 lectures to provide these figures

Future Directions

Questioning during interactive lectures can range from 0 to 100% of available time. At one end of the scale is traditional “Death by Powerpoint”; at the other end of the scale is full “Peer Supported Learning” with question delivery only. The subjective views of students sampled are a preference for a balance between content and question delivery. Good teachers naturally ask questions and seek feedback at intervals in order to hold the attention of students. The system described in this paper can be used to support rather than oppose good practice. By continuing to experiment with the proportion, variety and structure of questioning during different classes, it is relatively easy to establish the subjective preferences of students. What is necessarily harder is to establish more objective evidence on whether there is improved learning and better results (Horowitz, 2003). For example, interspersed questions are less appropriate for more reflective learning.

The greater reluctance to use interactive lectures comes from lecturers themselves. Reasons include:

- Lack of readily available hardware and software – at the University of Portsmouth staff can book mobile PRS hardware and software for rooms in which is not installed. It is planned to make RxShow more widely available.
- Authoring time – in our experience the addition of interactive Powerpoint questions adds an hour to the preparation time of a typical lecture. It is no harder to prepare questions than ordinary slides and the process might be speeded up by the use of wizards and question databases
- Delivery issues – Single key operation removes the need for any technical expertise, but questions inevitably take up lecture time.
- Limitation of question types - static and dynamic MCQs, dynamic numeric feedback, volunteer and conscript questions are all significant steps forward, but are only just scraping the surface of how live CAA can contribute to interactive lectures

Many further developments are possible, e.g.

- Static text feedback is currently displayed at the conclusion of a dynamic question (Figure 5). Verbal feedback can be given by the lecturer according to the answer distribution, but it would also be possible to display dynamic text feedback automatically according to the modal answer of the group. In this way a group could be “steered” towards a correct answer.
- Classroom communication systems (McCabe and Lucas, 1993), providing two-way communication between lecturer and students via PCs, open up a much wider range of possibilities, e.g. more question types, more varied feedback and greater control of delivery.

Drawbacks include greater expense and greater complexity of interaction. Nevertheless the idea of dynamic group response systems discussed in this paper could be extended to classroom communication systems. But lecturers would first need to get away from Powerpoint and embrace the wider opportunities which technology can bring to the classroom.

- Further work is already underway to evaluate the effect of dynamic peer supported learning on student attentiveness and results. One interesting question is whether weak students benefit from the teaching technique more than strong students.

Conclusions

It is often quoted that the attention span of students during lectures is limited to 10-15 minutes. Interactive questioning and dynamic student feedback can be used to enliven lectures by getting students actively involved. Dynamic peer supported learning is a powerful way of increasing that involvement.

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