TEACHING WITH CAA IN AN INTERACTIVE CLASSROOM
DEATH BY POWERPOINT - LIFE BY DISCOURSE

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Teaching with CAA in an Interactive Classroom Death by Powerpoint - Life by Discourse

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Abstract

We describe our experience with an advanced PC-based classroom communication system, Discourse, which allows live CAA-based classes to be delivered in ways that engage every student without the isolation and detachment of traditional CAA. Real-time student responses are received keystroke-by-keystroke allowing immediate feedback to be given by a lecturer. There is much greater variety in question types than available with wireless handsets, such as PRS, including open-ended and routing questions. Graphical hotspots, questions linked to specific Web sites and mathematical questions can be authored. Some questions can be authored and delivered "on-the-fly" to provide greater responsiveness. Students can even be asked to pose the questions themselves. Both social (synchronous) and self-paced (traditional, asynchronous) delivery modes are permitted. Feedback can be given in text, numeric and graphical form immediately using a range of styles from reports to charts. The administration of teachers, students, classes and courses is done via an integrated Discourse Manager.

Discourse is run from a small Web server on the "teacher" machine and is accessed from student PCs via a Web browser. A Discourse session could be delivered on-line, although it is primarily designed for face-to-face delivery. Unlike conventional CAA, the computer acts as an intermediary for communication with students allowing the lecturer to control delivery as much or as little as required. When used in a teaching computer lab the input devices are already in place, so no further costs are incurred. We have used Discourse for teaching in several different subject areas, including mathematics where students learn to use computer algebra software and in astronomy where existing question banks have been converted and adapted for Discourse lessons.

By comparing the best features of existing traditional CAA systems, handset systems and classroom communication systems the most desirable features of an interactive classroom system are identified. We conclude by speculating about future developments in classroom communication systems.

Keywords
Classroom Communication Systems (CCS), Group Response Systems (GRS), face-to-face CAA, student engagement, Discourse, Personal Response System (PRS), wireless network

Interactive Engagement

Past CAA conferences papers have described the use of group response systems for delivering live CAA in face-to-face teaching. Nicholls (1999) used the IML Question Wizard, Irving et al. (2000) describe their use of Teamworker and McCabe et al. (2001) discuss their use of the PRS system. The PRS system is being used increasingly widely, mainly because it is relatively cheap and simple to set up (Draper et al. 2003, Inverno 2003, Wit 2003). Furthermore, there are several ways in which PRS can be integrated with Powerpoint to make its delivery smoother:

RxShow	http://www.rxshow.com
Mitchell	http://www.dcs.gla.ac.uk/~mitchell/PRS/Downloads.html
IML	http://www.iml.ltd.uk/question_wizard.htm

The catchphrase "Death by Powerpoint" is frequently repeated and routinely ignored. The technology provides a convenient means of avoiding any *human* interaction or *human* engagement with students in a class. A lecturer can deliver a rigid set-piece, provide smart handouts, make the presentation available on-line and then walk away feeling that a good job has been done. The net result is little different from, or worse than, copying from a blackboard! The same could equally be said about computer based learning (CBL/VLE/MLE) or traditional CAA where authors inject content into software packages and expect students to engage with it remotely on an impersonal computer screen. Engagement with traditional CAA has some advantage in that its use by students is primarily motivated by the need to pass exams. Engagement in this context means *computer* engagement and interaction means *computer* interaction. Such weapons of mass (or math) instruction are not generally effective without some form of human involvement. In 25 years from now, will the university students of today remember an on-line course or a lecturer? The benefit of group response systems is that the technology can be used to promote human interaction and human engagement in large classes, and is not limited to computer interaction and computer engagement. The catch is that it takes skill to plan, set up and deliver engaging, interactive classes effectively.

When PRS is used (with or without Powerpoint integration) MCQ-type questions are asked by the lecturer, students respond via handsets and results are displayed for discussion. PRS increases class engagement and interactivity if it is used intelligently. Ways of using it effectively include short quick-fire tests at the start and end of a class, promotion of peer discussion among groups by asking questions during a class and evaluation of content/delivery at the start or end of a class. Live CAA questions are often quite different from traditional CAA by being simpler, more open-ended or even ambiguous. Breaking up a larger question into smaller subsidiary questions is often highly appropriate.

Other handset systems have different benefits and drawbacks. For example the CPS system allows students to work through a set of questions at their own pace. Yet, the first and most obvious drawback of PRS, CPS and many other group response systems is the limitation of their handsets and software to MCQ-type questions. Considerable ingenuity is used devise questions in a style suitable for live delivery, but the restrictive nature of the input can easily make classes tedious, unless it is used sparingly. Simply throwing in an occasional question to check understanding of a key topic is fine. This can be done easily enough if students own, or are loaned, handsets and lecture theatres are all equipped with the necessary receivers and software. Unfortunately though, not every classroom is PRS equipped and it may be necessary to bring in a laptop. Investment of, the albeit modest, time in setting up hardware and software, plus distributing and collecting handsets to 100+ students means that there is a strong temptation to exploit the facilities to the maximum extent possible. For this reason early use of PRS at Portsmouth has been during end-of-unit revision sessions in preparation for exams, rather than as a mainstream teaching tool. Even when adopting teaching pedagogies, such as peer instruction (Mazur 1997), there is a strong temptation to use more questions than necessary, not allowing enough time for reflection and discussion.

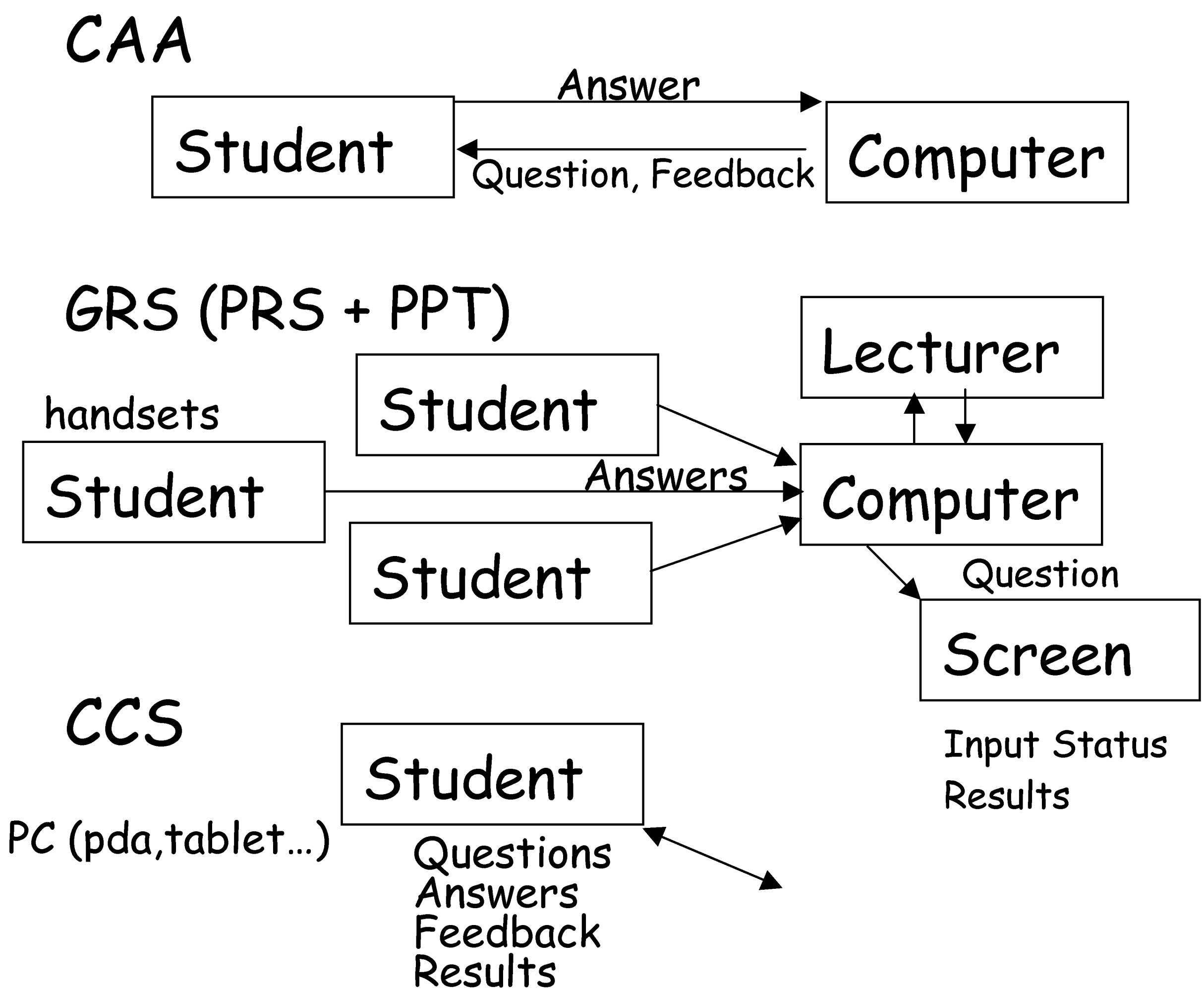
The second major drawback of standard handsets is that they are uni-directional, i.e. communication is one way from the student handsets to the central computer from which results are displayed to both students and lecturer. This limitation is overcome by the use of a Classroom Communication System (CCS). A CCS is essentially a bi-directional group response system, i.e. there is two-way communication from the student to the central computer controlled by the lecturer and from the central computer (lecturer) back to some or all of the students. This provides a much more varied and interesting range of human/computer interactions than is possible for a GRS. A CCS combines the benefits of traditional CAA (bi-directional, segregated users) with a GRS (uni-directional, linked users). Although traditional CAA is routinely delivered on-line nowadays, student users are still segregated. In theory, a traditional CAA system, such as TRIADS or QM Perception, could be adapted for live, in-class use during a computer lab, but unsuitable control of question delivery and the need for clear, immediate feedback to both lecturer and students hinders this type of use.

A third drawback of the PRS system is the inflexibility of its feedback. You get a frequency histogram every time whether you like it or not, adding to the risk of repetitive delivery. Pros and cons of using PRS are summarised in Table 1

Pros	Cons
small, lightweight, cheap handsets	limited to MCQ or simple numeric 0 – 9 questions
simple to use, cheap software on single PC	directional infra-red input; one –way communication
quite fast to set up	multiple receivers needed
portable system	weakly integrated question display (without add-ins)
timed questions	no self-paced delivery
add-ins available for PPT linking	no handset standard
student confidence input	inflexible feedback
administration and reporting facilities	handset battery maintenance

Table 1 Some Pros and Cons of the PRS Group Response System

The cost of input devices is important, especially when there are large student numbers Reusability of the input devices for other purposes also needs to be taken into acount. For a CCS these are necessarily PCs, but the advent of modestly priced PDAs, tablet PCs and wireless networking means that there is a standard alternative to handsets, which are highly non-standard and vary considerably from one manufacturer to another. Furthermore, the layout of a conventional computer lab can be rearranged to allow the use of existing facilities as a CCS. Schematically the differences between traditional CAA , a GRS and a CCS is presented in Figure 1 and Table 2



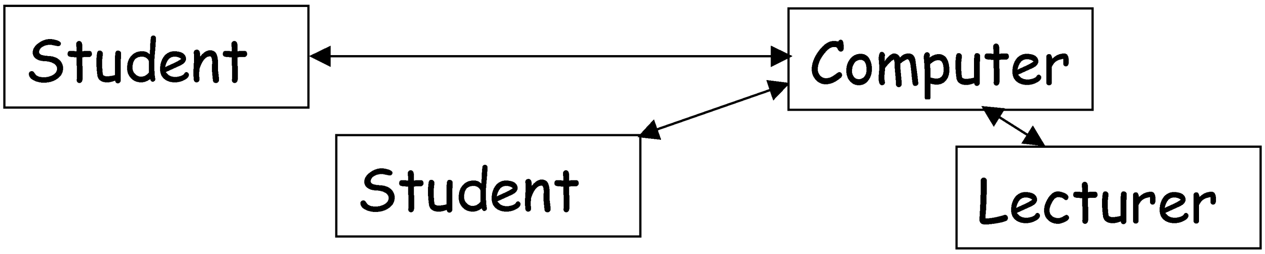


Figure 1 Schematic View of the Differences between CAA, GRS and CCS

	CAA	GRS	CCS
Student input device tablet/PDA	PC e.g. desktop	Handset	PC e.g.
Typical max numbers	500+	200+	30+
Communication	Two-way	One-way	Two-way
Question types	Many	Few (MCQ)	Many
Feedback screen	Private	Public	Private

Table 2 Characteristics of Traditional CAA, GRS and CCS

Pedagogy, Technology and Classroom Communication Systems

Teaching by questioning is as old as Socrates (469-399 BC) and yet the learning benefits of questions are still being analysed (Thalheimer 2003) and questioning plays a central part in many recently developed teaching pedagogies. For example, Mazur (1997) describes 'Peer Instruction' and Brookfield and Preskill (1999) describe 'Discussion as a Way of Teaching'.

Steve Draper at the University of Glasgow has created a useful set of links for the effective use of handsets and group response systems in teaching at http://www.psy.gla.ac.uk/~steve/ilig/. Use of classroom communication systems is far less common, because of the much higher cost of input devices. Yet Classtalk (Dufresne et al, 1996, Abrahamson 1998) was a sophisticated CCS, which used HP palmtop computers or TI graphing calculators successfully. Discourse was first introduced in the mid-1980s, though it is only relatively recently that its benefits for teaching in higher education are being recognised.

Discourse Teaching Environment

Discourse allows live CAA-based classes to be delivered in ways that engage every student without the isolation and detachment of traditional CAA, but without the limitations of standard group response systems. During the 2002/3 academic year two methods of delivering Discourse have been piloted (Figure 2).

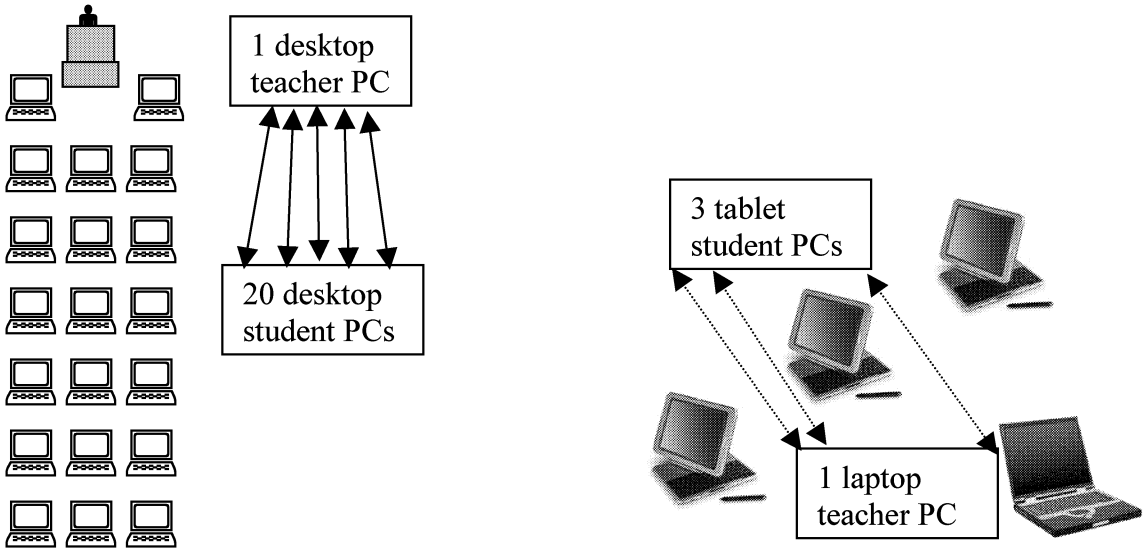


Figure 2 Discourse Set Up: a.) Networked PC Teaching Lab (left) b.) Wireless Network (right)

The first was in a teaching computer lab, where it was installed at the start of the academic year; the second was a small portable, wireless system which was tested towards the end of the academic year. Most computer labs are unsuitable for face-to-face teaching, normally being face-to-back as the lecturer peers over a student's shoulder to see their screen. A computer teaching lab in which the teacher PC faced the 20 student PCs in the class was an adequate, though not ideal location. It was already used for applications such as NetOpSchool, which allows a lecturer to control whether a student views the teacher PC or uses their local PC. The room layout with 7 rows of PCs was hardly conducive to personal communication, especially as the weaker students tended to congregate in the back rows. If Discourse could be successful in helping to engage students despite such an unsatisfactory room layout, then it would have overcome a significant obstacle. The teacher PC could have delivered Discourse to other PC labs simultaneously, but this would have defeated the purpose of the software in supporting face-to-face teaching.

In contrast to wired, network delivery a small wireless system of three tablet PCs linked to a teacher laptop PC has also been trialled (Figure 2b). It is planned to extend this system to nine or more student PCs in the future and to use both tablet PCs and PDAs. The advantages of this set up over the teaching lab are that it is portable and far less intrusive, e.g. it can be used while sitting round a table in any classroom. Face-to-face communication and full eye contact with students becomes possible, because they are no longer peering over flat-screen monitors. Whether used in horizontal screen (stylus mode) or vertical screen (keyboard mode) a tablet PC does not limit student visibility.

Discourse Delivery

Although a later version of Discourse was used on the portable system, the basic features of he software are the same. Real-time student responses are received keystroke-by-keystroke allowing immediate feedback to be given by a lecturer. Unlike PRS, where the lecturer sees the results at the same time as the students, Discourse allows the lecturer to see results in real-time as soon as students enter their responses. Students failing to participate can be picked up immediately and the correctness or validity of answers monitored. It is at the discretion of the lecturer whether to convey this information to students, either verbally or by using a range of software options for delivering feedback on student screens.

There is greater variety in question types than available with wireless handsets, including MCQ, FIB, keyword, open-ended and routing questions. When an MCQ is asked, the lecturer can see percentages/numbers choosing different choices or percentages/numbers choosing the correct answer.

Coloured bars show the information graphically. Figure 3 shows the authoring of an MCQ , including the mathematical equation editor (top left), a pie chart of responses (top right), the bar showing correct responses and list of student choices (lower left) and a report on an individual student (lower right).

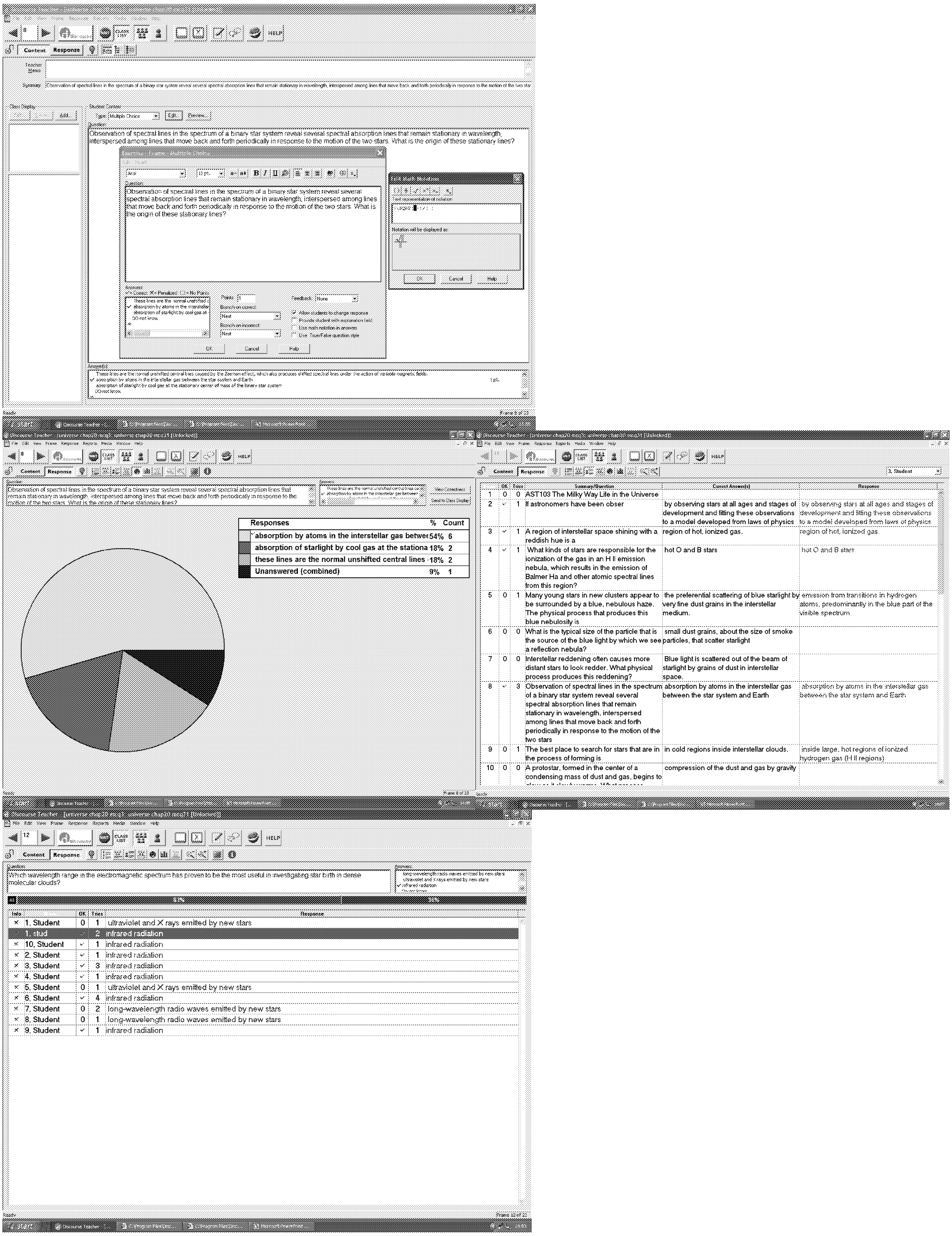


Figure 3 Authoring and Student Responses for Different MCQs

When an open-ended question is asked, e.g. Why do you think there was life on Mars? Or
Enter a discontinous mathematical function, answers are seen together on one screen as soon as they are typed. If the answer is mathematical, then all the different mathematical expressions entered by students can be seen

together. Responses to open-ended questions are not processed in any way, but the lecturer can choose to send some or all of the responses back to student screens with or without annotation for further discussion or comment. Although the software can handle large numbers of answers to open-ended questions perfectly well, complex responses can easily lead to information overload. In this pilot project, students have worked in pairs when all teaching lab PCs have been in use, but the number of student inputs has never exceeded 20.

The results of objective questions, can be presented as feedback in text, numeric, histogram or pie chart form at any time that responses are coming in. These results are initially viewed by the lecturer, who controls whether they are displayed to the students and can annotate them. The simpler question types can even be authored and delivered "on-the-fly" to provide greater responsiveness, as can basic information and reports on individual progress during or after the class.

Exercise Type (Frame) expressions	Question/Information	On-the-fly	Maths
Fill-in-blanks	Question	No	Limited
Hotspot	Question	No	No
Idea presentation	Information	No	Yes
Keyword	Question	No	No
MCQ	Question	No	Yes
True/False	Question	Yes	Yes
Open-ended	Question	Yes	Yes
Question & Answers (MRQ)	Question	No	No
Routing	Question	No	Limited
Voting	Question	Yes	No
Report	Information	Yes	No

Table 3 Discourse Question Types and Information Screens (Frames)

Graphical hotspot questions, questions providing controlled links to specific Web sites and mathematical questions are readily authored. In the latest version of the software, a basic mathematical input tool is available both for authoring some question types and for inputting of student answers.

A simple, but remarkably powerful, use of Discourse is simply to add: "Have you any questions?" as an open-ended question. Students frequently praise the anonymity afforded by group response systems in answering questions, but a CCS, such as Discourse, extends that anonymity to the asking questions as well. Indeed a question asked by one student may then be presented "on-the-fly" back to the whole class as another open-ended question. It is emphasised that Discourse is viewed as a tool, which primarily supports face-to-face teaching and that verbal discussion of questions and more traditional classroom interactions are never precluded. Discourse provides a powerful tool for "augmented teaching" which combines both computer and human interactions.

Both social (synchronous) and self-paced (traditional) delivery modes are permitted. In other words, the control of question delivery can be handed over from the lecturer to the students at any stage, allowing them to proceed at their own pace as during a normal CAA session. Table 4 shows how a class might be structured to exploit many of the Discourse features, although in practice it is found that remarkably few questions, sometimes as few as six, can occupy a full hour teaching session. Self-paced mode is used to conduct short pre-class or post-class tests, and social mode for the main interactive teaching.

PURPOSE	**EXERCISE TYPE**	
Introduction		
Structure/outline of class		IDP
Objective pre-test	Self-paced on previous class topic	MCQ x 5
Report on pre-test		REP
Any questions?		OEQ
Main session delivered in social mode, e.g. exploiting cyclical peer instruction		
Poll existing knowledge/understanding of current topic		VOT
Summary of session aims		IDP
Begin with open (subjective) questions		OEQ/VOT
Move towards more objective questions	KWD/QAA	
Use fill-in questions for text/numbers/algebra		FIB/ROT
Choice questions enable more precise feedback		MCQ/HSP
Any questions?		OEQ
Conclusion		
Poll knowledge/understanding of current topic		VOT
Objective post-test	Self-paced on current class topic	MCQ x 5
Report on post-test		REP
Any questions?		OEQ

Key to Exercise Types

Open questions — Word questions

Information

OEQ open-ended question — KWD keyword — IDP idea presentation

VOT voting question — QAA question and answer — RPT report

Fill-in questions — Closed choice questions

FIB fill-in-blanks — MCQ multiple choice question

ROT routing — HSP graphic hotspot

Table 4 Typical Interactive Class Using Discourse

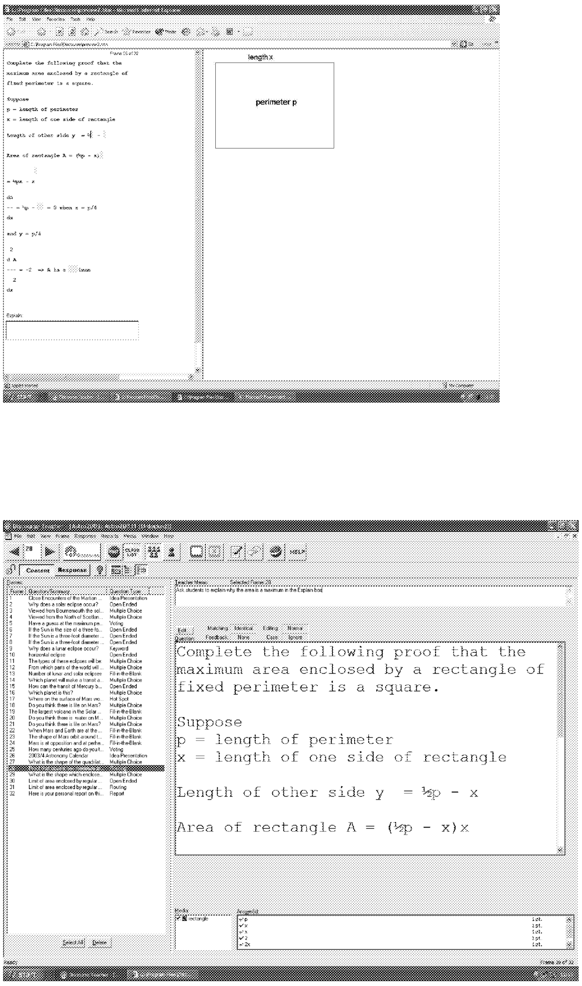


Figure 4 Editing and Previewing a Routing Question

The administration of teachers, students, classes and courses is done via an integrated Discourse Manager. For this pilot study, students logged in with a dummy, numbered user ID and password. Although genuine student names could have been used, the use of numbers helps maintain student anonymity when answers are displayed, while helping the lecturer to locate students according to their position in the room.

Discourse is run from a small Web server on the “teacher” machine and is accessed from student PCs via a standard Web browser (Internet Explorer). Although it is designed for face-to-face delivery, a Discourse session could be delivered on-line to the room next door and beyond. With additional video and audio facilities use of Discourse could, in principle, be extended to teaching at a distance.

Pros and cons of using Discourse are summarised in Table 5:

Pros	Cons
Greater range of question types, cf. GRS	Requires PC student input (desk/laptop, PDA,tablet)
Objective and subjective (open) questions	Most computer labs arranged unsuitably
Delivered on network or in wireless mode	Expensive input devices
Simple to use, cheap software on single teacher PC	Wireless delivery harder to set up
Well integrated system using standard browser	Lack of some question types cf. CAA
Standard input device	Authoring limitations, e.g. use of HTML
Keystroke-by-keystroke responses	Annotation with mouse tricky
On-the-fly question authoring	Lack of import/export facilities e.g. IMS QML
Mathematics tools, Web Travel …	Inflexible scoring
Administration and reporting	Lack of confidence levels cf. PRS

Table 5 Some Pros and Cons of Discourse

Case Studies

In this pilot study Discourse has been used for in the teaching of astronomy, mathematics and, to a lesser extent computing.

Case Study 1 Astronomy

Two level 1 elective units in astronomy have provided a good opportunity for introducing Discourse into teaching. Students on these units come from a variety of scientific backgrounds, but generally have no background in astronomy. The units are designed to attract and motivate earth scientists, biologists, mathematicians and geographers alike. Students are expected to read a textbook chapter, attend a (mostly Powerpoint delivered!) lecture and complete a weekly practical session. Observation sessions at a local observatory are optional and dependent upon the weather, so a variety of computer software and associated worksheets are used during the practical classes.

CAA is used for 50% of the unit assessment, tests being taken at approximately three week intervals. Since large databases of both formative and summative MCQs were already available, it was relatively straightforward, though tedious, task to edit them in Discourse (figure 3). The lack of facilities for importing questions slowed down the process, which required repetitive cutting-and-pasting . The important “Don’t know” option was always added and students were encouraged to use it whenever necessary. The MCQs were used in a revision class held the week before each test in a manner very similar to the PRS group response system, but with a greater variety of feedback options. Experimentation with other question types normally took place during a separate session. Conveniently each textbook chapter began with a series of open-ended questions, such as:

"How do you determine the temperature of a star?". These were often used at the beginning of a session, before moving on to more objective question types (Table 4).

It quickly became apparent that all students, even the weaker and less motivated ones, were participating, even if they did prefer anonymity towards the back of the room! On many occasions verbal questions or discussion was provoked by the Discourse feedback and authored questions were not used because of the extra time taken up. Powerpoint presentations rarely seem to have this problem.

Case Study 2 Mathematics and Computing

There are many different ways of teaching undergraduate students to use computer algebra software effectively. The classic approach is to use a balance of classroom lectures with software demonstrations and computer lab practicals. In the computer lab, student worksheets range from basic tutorials through to extended problem solving. Engagement with students takes place primarily at an individual level during these practical classes, with conventional CAA then used for summative testing of students' ability to solve problems with Maple.

In trials, some practicals were replaced by Discourse interactive classroom sessions, in which Maple was used to work out answers. While some of the conventional CAA questions could be used in Discourse, it was routinely found that these needed to be broken down into smaller questions in order to keep track of student progress. In this subject area the questions tended to be more objective and the role of Discourse was in maintaining control of the class, in monitoring progress and in provided feedback.

An interesting use of the routing question was in providing skeleton answers of mathematical working, which students were required to complete. Progress in filling in the missing details could be followed closely and assistance provided to those students who were failing to make progress or gave incorrect answers. Figure 5 shows how answers to a routing question can be tracked. Four students have finished the problem correctly (in green); two have made mistakes (in red) and three have not started.

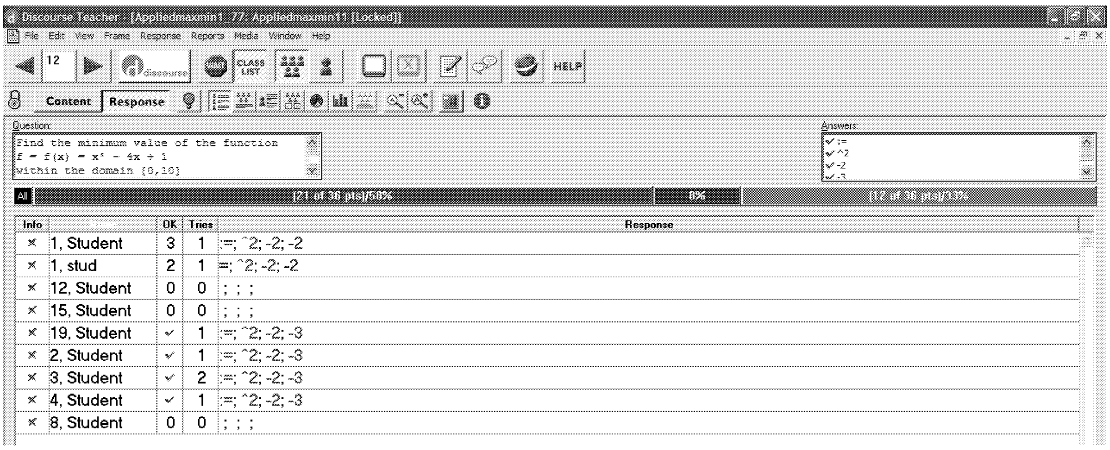


Figure 5 Live Tracking of Student Progress on a Mathematical Question

Although it does not provide any automatic numeric or algebraic answer checking, Discourse still provides a useful tool for mathematical questions. For example, algebraic questions can be delivered as open-ended, allowing for manual checking and selective return of answers to students for further discussion.

Past evaluation of Discourse has largely been in schools. Yet when university students routinely ask: "Can't we have classes like this more often?" it is impossible to ignore its potential for use in higher education. It is planned to conduct more formal evaluations, once regular use of Discourse is established.

Evolutionary Trends and the Future of CCS

An idealised classroom communication system might have the following properties:

- simple to install and use with large classes
- delivery of full range of question types – open, closed and mathematical
- lecturer or student controlled delivery modes
- two-way communication
- wireless, non-directional input
- low cost, compact, lightweight input devices (handset/PC)
- immediate, flexible display of graphical or numerical feedback
- networked or on-line

No such system exists yet, but it might in the future**.** CAA software normally has the greatest variety of question types, a GRS has the cheapest input devices while a CCS supports two-way communication of the lecturer with students.

It is interesting to consider how CAA and group communication have developed. CAA has evolved from optical readers to standalone, networked and on-line delivery.

CAA
1st generation 1975 – OCR/OMR (student ⇒ … computer … ⇒ student)
2nd generation 1990 – Networked computer based (computer ⇔ student)
3rd generation 2000 – On-line computer based (computer ⇔ student)

Group communication has advanced from low tech methods to group response systems and on-line tools, such as chat-rooms, where questions can be asked.

Group communication
1st generation low tech methods: hands, paper, cards, cubes (student ⇒ lecturer)

2nd generation	GRS one-way (student handset ⇒ computer ⇔ lecturer)
3rd generation communications	on-line chat-rooms, white-boards, VLE

Discourse, a CCS (student computers ⇔ lecturer computer) with two-way, on-line communication of CAA could be regarded as a 4th generation tool. While there is a rapid growth in on-line courses, there is remarkably an increasing demand for larger and better-equipped lecture theatres too. The ability of Discourse to deliver face-to-face and, theoretically, at a distance might well make it attractive in both contexts. At the very least, Discourse provides an exciting alternative to the mass slaughter from another Powerpoint presentation and handset "zapper" limitations!

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