COMMUNICUBES: INTERMEDIATE TECHNOLOGY FOR INTERACTION WITH STUDENT GROUPS

Stephen J. Bostock, Julie A. Hulme and Mark A. Davys

Keele University, UK

(p321-333 in *Audience Response Systems in Higher Education, applications and cases,* ed by D.A. Banks, 2006 Information Science Publishing)

Keywords

Pedagogy, Active Learning, Technological Innovations, Technology Mediated Learning, Higher Education

SUMMARY

This chapter describes an innovation supporting interaction between a teacher and a student group. It argues that there are five modes of engagement for students in groups. The mode of group interaction with a teacher can benefit from mediation by a voting, or response, technology. An exploratory pilot study of a novel, non-electronic, technology to support this mode is described. CommuniCubes enable every student in a group to vote individually on options presented to them. They were used by a large group in a stepped lecture theatre and by smaller groups in seminar rooms. The evaluation found the overall student response to be positive. The reasons students gave for CommuniCubes being both helpful and unhelpful to their learning are summarized. The costs and benefits of this technology and electronic voting devices are compared and the issues for further research are discussed.

MODES OF ENGAGEMENT

There is a continuing dilemma in higher education. The didactic lecture continues to be widely used with large groups yet the evidence is that it is ineffective for student learning (Bligh, 1998). It is used for reasons of tradition, efficient use of faculty time, and existing infrastructure. “For the individual learner, the lecture is a grossly inefficient way of engaging with academic knowledge.

For the institution it is very convenient, and so it survives." (Laurillard, 1993, p. 109). If lectures are only verbal information transmission, then student activity is restricted to listening and note-making. In contrast, we know that understanding requires "active learning" (Biggs, 2002): learning activities and interactions with other learners. In most universities face-to-face interaction between a student and a teacher is seen as essential to the quality of the learning experience. Theories of student learning stress the necessity of interaction such as dialogue or discussion (Mayes, 2001; Laurillard, 1993) but as a class size grows so the amount and quality of interaction with individuals is diluted.

There have been numerous responses to the problem of organizing learning activity and interactivity in large groups (Gedalof, 1998; Smith, 1997; Davies, 2003). One is to improve the lecture's efficiency of information transmission through improved performance and display technologies (Andreson, 1990). Another is to reduce the information being transmitted and include individual or small group activities (e.g. Bligh, 1998, chapter 19; Davies, 2003; Race, 2000, chapter 2; Brown and Manogue, 2001). Another is to use technology to facilitate responses to structured questions from all the students in a group, typically through electronic voting handsets. These personal response systems (PRS) vary in sophistication from those supporting simple, anonymous voting to those providing individual feedback (e.g. McCabe and Lucas, 2003; Wit, 2003; d'Inverno, 2003; Draper and Brown, 2004; McCabe, 2004; Draper, 2005).

There are numerous lists or classifications of teaching-learning activities (e.g. Biggs, 2002; Laurillard, 1993; Shuell, 1992; Conole and Oliver, 1998; Hegarty, Bostock and Collins, 2000), some fine-grained and others broader. The following list seems especially appropriate for face-to-face teaching. Concentrating on student engagement in the teaching-learning situation, we suggest there are generally five types of teaching/learning activity (Brown and Manogu, 2001), *five modes of student engagement in groups.*

1. Transmission/reception

   A didactic transmission of information involves the teacher talking and possibly writing notes ("chalk and talk") or displaying a transcript. This places the students in a passive role, with their cognitive activities limited to listening and taking notes, which for most students is unlikely to result in understanding at the time.

2. Multimedia transmission/reception

   Enhanced presentations use additional media to bring impact and realism to the information transmission. This might take the form of integrated digital multimedia presentations, but not necessarily, for example, demonstrations, images, sounds, video, and debates between tutors. Students see and hear more realistic or more applied situations, in more memorable forms. It may present the content of learning rather than talk about the content in mode 1.

3. Individual activity

   Individual student learning activities can be prompted, for example, by a teacher asking students to solve a problem, answer a question, ask a question, write a "one-minute essay" (Draper 2005), or complete a gapped handout. Such learning activities are an opportunity for students to rehearse and apply new information or practice skills.

4. Student interactivity

   Interactions between students in small groups can be organized within large groups, even in the most restrictive of circumstances such as a tiered lecture hall. Students can be asked to work in small groups to solve problems, write questions, or debate disagreements.

5. Student/teacher interactivity

   Teacher-student interactions in real time with a face-to-face group gives the teacher immediate feedback on student performance or opinion, and gives students immediate feedback on their own performance. It requires a mediating technology, generically termed a personal response system (PRS) or "keypad". Without a PRS we must rely on shows of hands and volunteering but both have limitations, especially for weak students.

In mode 2, technology may be used to facilitate transmission of information. While modes 3 and 4 do not necessarily require technology, a problem occurs in large groups when we want to consolidate the results of these individual or small group activities: We can select possibly representative students, or ask for volunteers, but we cannot get a poll or representative sample of results easily and quickly. We can ask for the results on paper and compile them for the next session, but we then delay the discovery of student performance and lose an opportunity to give immediate feedback to students, which reduces its value. While student activities and interactivities (modes 3 and 4) may not involve technology, only in mode 5 are the advantages of immediate, two-way feedback possible for student groups. A PRS can demand interactivity from all students, who then get feedback on their individual conceptions and skills. Student voting gives feedback to a teacher on student learning so that she can immediately adapt her teaching to respond to their current needs. A PRS can demand participation, and thus attention, from all students and avoiding the need for volunteering.

No single mode is best and each may be valuable in some circumstances. There is a general educational argument for a variety of teaching methods in lectures (Bligh 1998, 228), so effective lectures would often use a mix of some or all modes. Different sequences of these modes, in other terms, have been developed (Saroyan and Snell, 1997; Boyle and Nicol, 2003; Agnew, 2005). Students rate lectures with student or teacher interactivity high, and rate didactic, formal lectures very low (Saroyan and Snell, 1997; Sander et al., 2000).

While the discussion above was made in terms of "large groups", how large is large? Gedalof (1998) considers 50 as the threshold for a large group, on the grounds of the possibility of individual contact with students in the time available, and of being able to remember their names. Therefore, a class of, say, 15 might not seem to qualify as a "large group". It is not large if problems of one-way *transmission* (modes 1, 2) are being considered. However, we are now concerned with the impact of group size on the quality of the *interaction with a teacher* (mode 5), and this might be assumed to be in proportion to group size. Reducing the quality or frequency of a one-to-one interaction to one fifteenth of that is a very significant reduction, even if it is less severe than reducing it to one fiftieth. It is this reduction in the interaction possible with individual students that makes the mediation of the communication by a voting technology potentially advantageous in groups of any size.

PERSONAL RESPONSE SYSTEMS

The thoughtful use of a PRS has delivered educational benefits in a range of subjects (e.g. Stuart et al., 2004; Young, 2001; D'Inverno, 2003; Uhari et al., 2003; Elliott, 2003; Purchase et al., 2004). The snags with mode 5 are the reliance on complex technology, and its cost. The costs of a basic electronic PRS will no doubt continue to fall but, for the time being the cost is significant, especially for large groups. It is not easy to demonstrate to an institution that this is a wise investment in student learning. In North America it seems possible to shift the cost of handsets to students, in institutions where the detection and display equipment is widely used. In the UK, this is unlikely. Another cost is training faculty to use the equipment and educating them to design new lectures to make best use of it. As with any new technology, there will be a minority of staff prepared to take a risk, spend their own time, and try it. However, for students to encounter engagement mode 5 as frequently as other modes, most faculty must use it. For many faculty, the time costs and the risks of dependency on the technology are significant disincentives. A lecture designed to use a PRS will struggle if it fails, with damage to learning and to faculty prestige.

Manual methods of attempting student-teacher interaction in medium-sized and large groups are well established: a show of hands to vote on a question, or asking for volunteer answers or questions. There is no technology and so no risk of it failing but, unfortunately, for most students it is not effective. Volunteers are unrepresentative. A dependence on volunteering means that participation is not required of all students but is optional, for a minority, and the weaker students do not participate.

Between these two ways of mediating student-teacher interaction, electronic and manual, is the possibility of “intermediate technology” (Schumacher, 1974, p. 128): “a *different* kind of technology, a technology with a human face, which instead of making human hands and brains redundant, helps them to become far more productive than they have ever been before”. Innovative teachers in the past have used coloured cards or similar devices with which every student can/must vote (Cavanaugh, 1996; Harden et al., 1968 and Dunn, 1969 are cited in Elliott, 2003). How effective can such mechanical devices be? Can we gain most of the educational benefits without the electronics? The remainder of this chapter considers an exploratory pilot study of one such device, and an initial evaluation of its use with medium-sized and large student groups.

CommuniCubes

The desirable properties of a voting device include permitting individuals to indicate a choice of 4 or 5 options, quickly, easily and reliably; for counting the votes quickly; and displaying them if the teacher so desires. Simple mechanical aids such as coloured cards have some disadvantages over an electronic PRS: an element of volunteering is still present if students must hold them up; students may make errors in the process of translating their choice into a colour to be shown to the tutor; there are only a small number of options; and there is no automatic counting. The CommuniCube was designed to minimise these difficulties, without incurring the risks and costs of electronic devices.

CommuniCubes are lightweight, 10 cm cubes, small enough to be hand-held and large enough to be visible in a lecture hall seating 400. Five of the cube faces have contrasting, bright colours designed to be distinguished in poor lighting. The sixth (top) face has a design that maps a number (1 to 5) to each of the five coloured faces (Figure 1). CommuniCubes work most easily when they can rest on a surface in front of each student. When a student rotates their cube to read the number of their selection, a particular coloured face is thus presented to the teacher. Students need not be concerned with the colour to display, removing possible errors in displaying their choice. If only four choices are needed, the cube is simply rotated with the map face on top. If the choice made is number 5, the cube is flipped so the map faces the student and the fifth face is presented to the teacher.

It takes one or two minutes to train students to use it. Blind students can just as easily use a Braille version or one with numbers as ‘bumps’. Training faculty in its use involves learning a script to instruct students and practice in counting or estimating the numbers of different colours being displayed. The manual counting or estimation of colours is not a difficulty, as accuracy is usually not needed. The colours were checked for use with red-green colour blindness in the teacher; students do not use the colours, only the map face, so visual impairment is not an issue for them.

While no automatic record of individual voting can be made, a mechanical system makes additional information available to the teacher. The pattern of voting across a lecture theatre is immediately clear. Frequently those sitting at the back vote differently from those at the front, for example. Also, voting in a lecture theatre is semi-anonymous between students as they cannot see many other students’ cubes, but it is not anonymous to the teacher who will probably recognise particular students and their voting selection. This is additional useful information in understanding the range of student performance or opinions.

The types of questions that can be asked are the same for CommuniCubes as with an electronic PRS: about factual content, answers to problems, personal views or experience, preferences for future topics, and so on. The result of voting is measured by the teacher or an assistant, by counting the cube faces of different colours in smaller groups, and estimating their proportions in larger groups. After voting and counting, the third stage is giving feedback to students on the result. Often, a verbal report is all that is needed. Where there are more options and the students will benefit from seeing more accurate results, two types of pie chart displays have been used. Where a computer display is being used, a spreadsheet with a pie chart for each of the number of options (2 to 5) displays the result as numbers are entered. A second display option is a mechanical pie chart, large enough to be visible in a lecture hall, where each sector is revealed by sliding its handle around the graduated circumference. This is even quicker.

AN INITIAL EVALUATION

The CommuniCubes were evaluated in 2003-4 in two types of student groups: lectures with 120 first year psychology students (taught by JH, Figure 2) and seminars with 15 to 25 law students in their second or third year (taught by MD). Every student had a CommuniCube. They were used in the second semester, so the groups had experienced similar teaching situations without any voting technology and therefore had a basis for comparison. Teaching periods were one hour.

The teaching methods were different to those in the lecture theatre, as were the uses made of the CommuniCubes. In the lecture theatre, voting was used for “concept checking”: after a short exposition of a concept (mode 1) a multiple choice question checked understanding (mode 5) before proceeding to the next concept. The lectures proceeded as an alternation of engagement modes 1 and 5. In the smaller seminar groups, voting was used for revision and for answering a case problem prior to students being divided into working groups on the basis of their answer, that is, to launch peer discussion (Draper and Brown, 2004). This used modes 1, 3, 4 and 5.

To minimize the effect of novelty, a questionnaire was administered after three or four weekly sessions (Figure 3). The total numbers of students responding to the questionnaire were small (41); all of the law students and a small proportion of the psychology students (who probably suffered from questionnaire fatigue). The “litmus test” question of whether students would recommend further use of the cubes was answered positively by 73%, with a similar pattern in Psychology and in Law (Figure 4). Responses to the question about the net advantage of the cubes to their learning were overwhelmingly positive (Figure 5). The modal value overall was “a significant advantage”, although for the Psychology students it was between that point and neutral (4 on the scale).

To gain some insight into why students thought the use of the CommuniCubes helpful or unhelpful, the questionnaire asked students to give up to three reasons why they were advantageous to learning, and up to three why they were not. The answers to these open questions were categorized and scored by how frequent a type of answer was given and how important it was said to be: a score of 3 for the most important, two for the second and one for the third. Here the two groups gave somewhat different answers (Figure 6), no doubt reflecting how they were used and the physical arrangement of the students in the rooms. In the lectures, the most important reasons for the cubes being helpful were getting feedback on understanding and being fun. In the seminars, there was little anonymity in making responses with the cubes and the most important advantages given were about everyone being forced to participate. No doubt, students' perceptions of the usefulness of the technology were related to how they were asked to use it.

The disadvantages to learning given in the lectures were worries about the lack of anonymity in voting, the time taken to vote, and to collect and replace the cubes at the start and end of the lecture. In the seminars, these reasons were also given, plus a few worries about multiple choice questions limiting the responses that could be made about the more discursive content. It is interesting that both groups gave the lack of complete anonymity as their main worry. This may reflect an unnecessary concern about displaying the right answer (given that this was formative assessment and not recorded or graded) rather than displaying their own understanding. It may be that more emphatic guidance on the purpose of using the cubes could overcome this, or it may be that our students are just too easily embarrassed. However, as Figure 5 and the lower scores in Figure 6 demonstrate, students volunteered far fewer disadvantages than advantages.

There is no intention to make comparisons based on the academic level of students or their subjects, as these were confounded with the group size and style of teaching. There was no control group in this data, nor could a valid control be arranged. (How could students who had not used a voting technology offer an informed opinion about one?) The students who used the cubes, and responded to the questionnaire about their use, were comparing their experiences with the cubes to previous teaching-learning situations without them. Furthermore, the data only attempt to measure immediate reaction to the technology, rather than the impact on course learning outcomes or longer term effects (Kirkpatrick, 1994). This would need a larger study. While the data only represent student perceptions, these are an important contributor to learning outcomes.

DISCUSSION

Learning for understanding requires students to engage with the subject through intellectual activities (Biggs, 2002). Many university students and faculty continue to value the dialogue possible in a face-to-face teaching and many courses continue to schedule seminars and lectures. However, increasing student numbers in many places erode their effectiveness by diluting the dialogue. Without thoughtful design, classes easily degenerate into mere transmission of information (mode 1), which is known to be ineffective for student learning (Bligh, 1998; Laurillard, 2001). While interactivities within small student groups are valuable, they fail to make full use of the discipline and pedagogical expertise of the teacher. This interaction needs to be mediated by a technology by which all students make a response; interaction between a teacher and a group by traditional methods (volunteering, shows of hands) is ineffective for many students.

Electronic personal response systems have been found to be effective when used by innovative teachers (Draper, 2005) but they are expensive and they make the teacher dependent on complex equipment. CommuniCubes are designed to fill this gap: an intermediate technology that is cheap and simple, cannot break down, and is good enough for the purpose of requiring multiple choice responses from all students in a group. This initial evaluation suggests that they can be effective both in lectures and seminars.

Every technology has its strengths and weaknesses (Figure 7). Electronic PRS are improving and becoming gradually cheaper. Their software can store question banks and individual student responses, although this is not necessarily welcomed by students (Elliott, 2003). Some advanced versions can give automatic, individual feedback (e.g. McCabe, 2004) but these special capabilities require staff effort to design and come at yet higher cost. Their use as mainstream practice is unlikely for some years to come, even in developed countries. It seems likely that they will remain the expensive research tool of e-learning enthusiasts for the time being.

CommuniCubes, on the other hand, are designed to have just enough functionality to support multiple-choice questions and thus still stimulate student engagement. The initial evaluation has justified this hope. Their cost depends on the exact construction. Those used in these first experiments were cut from high density foam and spray painted. They suffered from the experiments of all prototypes and eventually cost $20 each. However, the construction is flexible. CommuniCubes that are assembled from a printed card are available at a much lower cost, and are thus effectively disposable.

CommuniCubes will be further evaluated in a wider range of disciplines and situations. This study indicates that issues worth investigating in future include the importance of anonymity of voting (to fellow students and to the teacher); the compulsion to vote rather than merely the ability to do so; the impact of the prior knowledge that a voting device will be used on student's preparation and performance in class; and more detailed comparisons with an electronic PRS in terms of pedagogical flexibility and cost-effectiveness.

Even if electronic PRS become more widely available, CommuniCubes may prove to be a useful way to introduce faculty to designing more interactive sessions for student groups. They can experiment with pedagogical designs that mix the five modes of engagement without the equipment and training needed with an electronic system, and its perceived risks. They require no complex equipment or even electricity. They may thus prove particularly useful in developing countries.

Contact address:

Dr Stephen J Bostock

Staff Development and Training Centre

Keele University

Staffordshire

UK ST5 5BG

s.j.bostock@keele.ac.uk

Figure 1

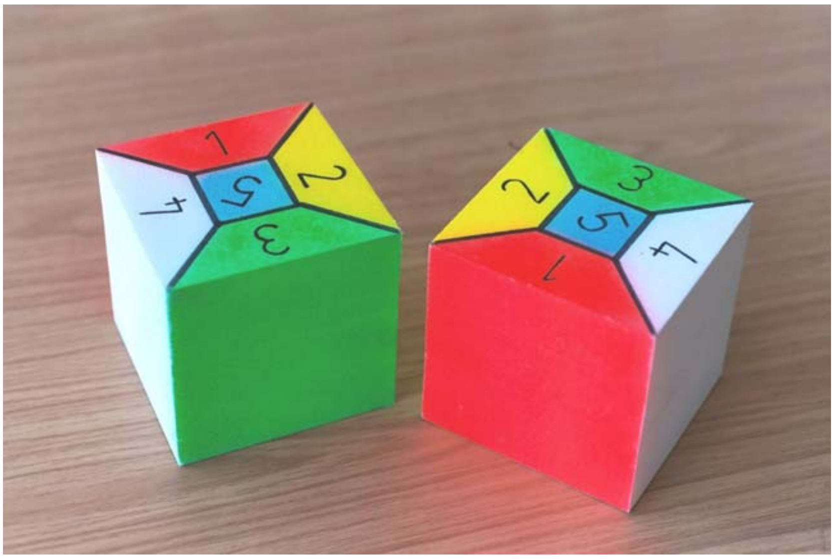

Figure 2

Figure 3 The questionnaire (compressed)

Question A. How do you think use of the cubes has been helpful to your learning? (up to three reasons)

1. The most important reason is ...
2. The next most important is ...
3. The next most important is ...

Question B. How do you think use of the cubes has been unhelpful to your learning? (up to three reasons)

1. The most important reason is ...
2. The next most important is ...
3. The next most important is ...

Question C. On balance, how do you rate the net advantage/disadvantage to your learning experiences of using the cubes? (put a cross against one number on the scale)

From my experience of using the cubes, on balance I think there is :

(a horizontal line with the scale marks left to right)

1 an overwhelming advantage

2

3 a significant advantage

4

5 no overall advantage or disadvantage

6

7 a significant disadvantage

8

9 an overwhelming disadvantage

10

Question D. Would you recommend we use the cubes in this course next year?

(please circle an option) yes/ no/ maybe

Question E. Any other comments?

Figure 4 Would you recommend we use the cubes in this course next year?

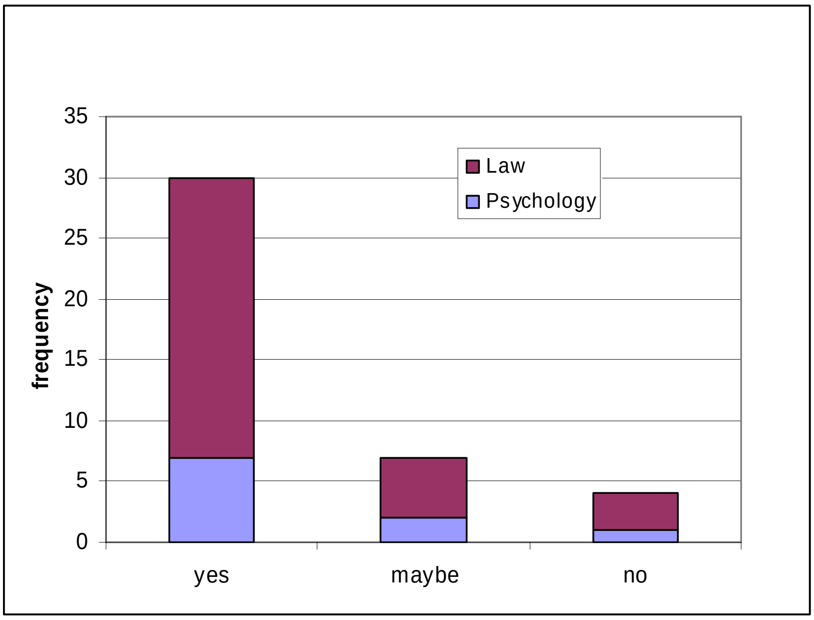

Figure 5 The net advantage to your learning

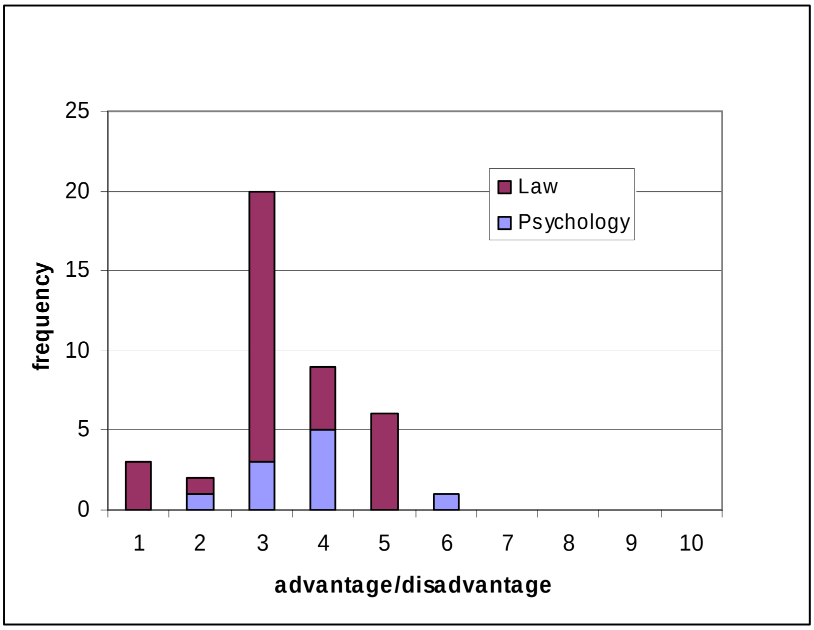

Figure 6 Reasons for the CommuniCubes being helpful and unhelpful to learning.

Higher scores are more frequent or more important answers. The answers to open questions were categorized and scored by how frequent a type of answer was given and how important it was said to be: a score of 3 for the most important, two for the second and one for the third. Scores for each category were then totalled.

Scores for the different reasons given	Psychology students in lectures	Law students in seminars
Number of students responding	10	32
Reasons helpful to my learning (scores)		
Gave me feedback on my understanding	12	4
It was fun, interesting, variety	12	6
Participation, made me think, contribute, be involved, express an opinion	8	69
Preparation for the sessions improved	-	5
Can express an opinion without embarrassment	-	16
Can see other's opinions and work with them	-	12
Reasons unhelpful to my learning (scores)		
Can get the answer from seeing others' votes	12	13
A distraction, irrelevant	9	-
Slowed things down, wastes time	7	15
Had to make a decision too quickly or when undecided	-	8
Limits the options to respond or discuss	-	11

Figure 7 Cost effectiveness

	CommuniCubes	Electronic PRS
Weaknesses and risks		
Apparent risks of equipment failure	Nil	Significant for novice users
Price per handset	$1 - 20	$120
Staff training	10 minutes	1 hour
Student training	1 minute	1 minute
Time to set up detection and display equipment	nil unless a pie chart display is wanted	10-15 minutes unless permanently installed
Distribution and collection of handsets	5 minutes depending on numbers and room	5 minutes depending on numbers and room
Strengths and opportunities		
Number of possible responses	5	8 or 10
Response time	Under 1 minute	Under 1 minute depending on the system
Counting	Done by teacher	Automatic
Display of data	Done by teacher optionally	Automatic
Storage of individual results	Not possible	Possible
Topological patterns	Automatic	Difficult

REFERENCES

Agnew, C. How do I encourage active learning? *The resource database: Geography, Earth and Environmental Sciences.*
http://www2.glos.ac.uk/gdn/abstracts/a116.htm
Accessed 19 April 2005

Andreson, L. (1990). Lecturing to large groups, in Rust, C., *Teaching in Higher Education*, SCED Paper 57, Birmingham, UK: SCED Publications.

Biggs, J.B. (2003). *Teaching for Quality Learning at University*. Second edition. Buckingham: Society for Research in Higher Education & Open University Press

Bligh, D. (1998). *What's the use of lectures.* 5th edition. Exeter: Intellect.

Boyle, J.T. & Nicol, D.J. (2003). Using classroom communication systems to support interaction and discussion in large class settings. *Association for Learning Technology Journal* (*ALT-J*, 11(3), 43-57.
http://www.psy.gla.ac.uk/~steve/ilig/papers/nicol1.pdf
Accessed 19 April 2005

Brown, G. and Manogue, M. (2001). AMME Medical Education Guide No.22: Refreshing Lecturing: A Guide for Lecturers. *Medical Teacher*, 23 (3), 231-244.

Cavanagh, R.A., Heward, W.L. & Donelson, F. (1996). Effects of response cards during lesson closure on the academic performance of secondary students in an earth science course. *J. Applied Behavioural Analysis*, 29 (3), 403-406.

Davies, P. (2003) *Practical ideas for enhancing lectures.* SEDA Special 13. Birmingham, UK: Staff and Educational Development Association.
http://www.seda.ac.uk/

D'Inverno, R. (2003). Making lectures interactive. *MSOR Connections*, 3 (1), 18-19

D'Inverno, R., Davis, H. & White, S. (2003). Using a personal response system for promoting student interaction. *Teaching Mathematics and its Applications*, 22(4), 163-169.
http://eprints.ecs.soton.ac.uk/9202/
Accessed 19 April 2005

Draper S. (2005). *Interactive lectures.*
http://www.psy.gla.ac.uk/~steve/ilig/il.html
Accessed 19 April 2005

Draper S.W. & Brown, M.I. (2004). Increasing interactivity in lectures using an electronic voting system. *Journal of Computer Assisted Learning*, 20 (2), 81.
http://www.blackwell-synergy.com/links/doi/10.1111/j.1365-2729.2004.00074.x/abs/
Accessed 19 April 2005

Elliott, C. (2003). Using a personal response system in economics teaching. *International Review of Economics Education*, 1 (1), 80-86.

Gedalof, A.J. (1998). *Teaching large classes.* STLHE Green Guide Number 1. Halifax, Canada: Society for Teaching and Learning in Higher Education.

Hegarty, J.R. Bostock, S J. & Collins, D. (2000). Staff development in information technology for special needs: a new, distance-learning course at Keele University. *British Journal of Educational Technology*, 31 (3), 199-212.

Kirkpatrick, D. L. (1994). *Evaluating Training Programs: The Four Levels.* Berrett-Koehler, San Francisco 1994.

Laurillard, D. (1993). *Rethinking University Teaching: A Framework for the Effective Use of Educational Technology*. London: Routledge.

Mayes, J.T. (2001) Quality in an e-University. *Assessment & Evaluation in Higher Education,* 26 (5), 465-473.

McCabe, M. & Lucas, I. (2003). *Teaching with CAA in an interactive classroom.*
http://www.psy.gla.ac.uk/~steve/ilig/papers/mccabe2.pdf
Accessed 19 April 2005

McCabe, M. (2004) Talking the MICK: What is a mathematics interactive classroom kit? *MSOR Connections*, 4 (1), 21-27.

Purchase H. C., Mitchell C. & Ounis I. (2004) Gauging Students' Understanding Through Interactive Lectures. *Key Technologies for Data Management*. 21st British National Conference on Databases, BNCOD 21, Edinburgh, UK, July 7-9, 2004, Proceedings, Editors Williams, H. & MacKinnon, L.
http://staff.psy.gla.ac.uk/~steve/ilig/papers/hcp1.pdf
Accessed 19 April 2005

Sander, P. Stevenson, K., King, M. & Coates, D. (2000). University students' expectations of teaching. *Studies in Higher Education*, 25, 309-323.

Saroyan, A. & Snell, L. S. (1997). Variations in lecturing styles. *Higher Education*, 33, 85-104.

Schumacher, E.F. (1974). *Small is beautiful*. London: Abacus.

Shuell, T. (1992). Designing Instructional Computing Systems for Meaningful Learning. In Winne P. & Jones M. (eds) *Adaptive Learning Environments: foundations and Frontiers*. New York: Springer-Verlag.

Smith, B. (1997). *Lecturing to large groups*. SEDA Special 1. Birmingham, UK: Staff and Educational Development Association.

Stuart, S.A., Brown, M.I. & Draper, S.W. (2004). Using an electronic voting system in logic lectures: One practitioner's application. *Journal of Computer Assisted Learning*, 20 (2), p.95.

Uhari, M., Renko, M. & Sioni, H. (2003) Experiences of using an interactive audience response system in lectures. *BMC Medical Education*, 3 (12).
http://www.biomedcentral.com/
Accessed 19 April 2005

Wit, E. (2003). Who wants to be …The use of a personal response system in statistics teaching. *MSOR Connections*, 3 (2), 14-20.

Young P. (2001). *Why use interactive lectures?* Social Policy and Social Work Subject Centre, UK Higher Education Academy.
http://www.swap.ac.uk/learning/Interactive2.asp
Accessed 19 April 2005