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An evaluation of active lecturing in a computer networks course

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ABSTRACT: The article describes an attempt to improve student learning outcomes in a computer networks course by making lectures more active learning experiences. Quick quizzes, group and individual exercises, the review of student questions, as well as multiple breaks, were incorporated into the weekly three-hour lectures. Student responses to the modified lectures was overwhelmingly positive: over 85% of respondents agreed that the lectures aided understanding, with large majorities of the respondents finding the individual activities useful to their learning. Although student examination performance improved over the previous year, performance on an examination question that was designed to examine deep understanding remained unchanged.

INTRODUCTION

The classic work on the use of lectures in higher education is that by Bligh [1][2]. Drawing on many previous studies of the effectiveness of lectures, Bligh argues that lectures are as effective as any other method for transmitting information, but most lectures are not as effective as more active methods for the promotion of thought. In these arguments, the term *lecture* is taken to mean a *period of more or less uninterrupted talk from a teacher*. An *active lecture* can be considered to be one in which the student plays an *active*, rather than a *passive*, role, ie the student participates in activities other than just listening to the lecturer.

This article describes an attempt to make lectures in a computer networks subject more active learning experiences. The subject (Computer Networks I) is a first course in computer networks aimed at students studying technical degree programmes such as the Bachelor of Information Technology and Bachelor of Engineering (Electrical, Software, Computer Systems). The course is also available to students in more general programmes (BA, BSc). Although recommended for third year students, the prerequisites are such that the course can be (and is) undertaken by second year students.

In the year of this study (2001), the course was offered at two campuses to a combined enrolment of approximately 350 students. Lecture sessions were timetabled as a single three-hour block per week (at each campus), with the author responsible for half of the lectures.

In previous years, the lectures were transmissive in nature, with little activity required on the part of the students. The aim of this study was to make the lectures more active learning experiences with the ideal aim of improving student understanding of the material.

BACKGROUND

Many studies have investigated active lecturing. Steinert and Snell define interactive lecturing as that encouraging active participation on the part of the teacher and the student [3]. They list five general principles for educators to become more interactive:

- Be willing to take risks and overcome your fears;
- Prepare and practice;
- Be clear in your objective and cut down on your material;
- Prepare students for their role in interactive lectures;
- Remain flexible and do not overdo it.

Murray and Brightman discuss the use of *interactive teaching* in engineering lectures and provide concrete suggestions for practical implementation [4]. Tips are provided for lecturers in particular contexts, including those not involved in either curriculum design or assessment for the course being taught (similar to the situation faced here). A mixture of the following items (some used more than once per lecture) is suggested:

- Lecture: 20 minutes maximum at any one time;
- Discussion task: (5 minutes) students discuss in pairs;
- Thinking task: (5 minutes) students compare answers;
- Writing task: (5 minutes) for peer review, not for assessment.

No experimental evidence is given to support this approach, but ideas are drawn from the wider literature. Marbach-Ad and Sokolove, working in the area of introductory college biology, conducted a study of two groups of students taught the same material in different ways (in different semesters) [5]. One group was taught using a traditional lecture approach, the other with an active learning approach. Students taught using the active learning approach demonstrated a deeper understanding

of the content (as evidenced by the quality of written questions submitted by the students).

Jenkins describes the concept of the structured lecture as a cross between a conventional lecture and discussion-based teaching [6]. A structured lecture combines small group discussion, problem solving, with some *lecturettes* where the lecturer speaks to the class for up to 10 minutes. Structured lectures provide *effective* learning opportunities in which students actively participate along with the *efficiency* of conventional lectures where large numbers of students can be taught concurrently. Jenkins notes that a critical issue in the success of structured lectures is the appropriate selection or construction of tasks for students to undertake. One of Jenkins' suggestions is the use of *concrete examples, specific situations and contexts with which students are familiar, rather than abstract, general and unfamiliar problems* [6].

ACTIVE LECTURING TECHNIQUES

Many authors have written on the topic of lecturing tips and techniques. Gibbs et al describe 53 techniques that can be used to make lectures more *interesting* [7]. Many of the techniques described are what Biggs would describe as *Level 2* activities on his three-level scale of teaching competence, ie they are focused on what the teacher does, not on what the student does [8]. As Biggs notes, these activities are important for *setting the stage for good learning to take place – not as an end itself*.

Some of the techniques described by Gibbs et al can be classified as *Level 3* activities, ie they focus on what the student does and what learning is or is not going on [7]. Such lecture activities include: buzz groups, reading and quiet time for reflection. Some techniques also check on learning, such as quick quizzes, having students list the three most important points from the lecture and review tests at the beginning of lectures [7].

Small Group Discussion

Studies, such as that by Borreson, demonstrate better results (in terms of final grades) for students who worked in groups than for students working individually in another class on the same course content [9]. Bligh, Weimer, and Meyers and Jones, plus others, describe how group work can be used in-class [2][10][11]. There is varying advice on the size of groups, composition of the groups, and amount of time on the task. The nature of the task should almost always be open-ended and require discussion, rather than be uninvolving and requiring recall or simple calculation. However, Bligh recommends that the tasks not be completely open-ended, eg the form *List three reasons for …* should be used in preference to *Why do you think …* [2].

Meyers and Jones note that

> *Small-group activities are educationally sound only insofar as we carefully design realistic goals, guide students' behavior, and create a positive atmosphere in which students will share their ideas and learn from each other* [11].

They also suggest starting group activities with individual writing (eg response to a question) [11]. This has the advantage of encouraging participation by all students, as well as clarifying student thinking before discussion occurs. Bligh outlines a number of possible objectives for buzz-group use and classifies these into three groups, namely: the acquisition of knowledge (including clarification and consolidation of understanding); the promotion of thought (eg evaluative thinking); and the cultivation of attitudes and feelings (eg building the confidence of reticent students) [2]. Meyers and Jones also recommend that the particular objective of a group activity is limited to one or two key goals, as it is unlikely that students can focus on multiple outcomes [11].

Windschitl reports on a study of two professors who introduce small-group discussions into traditional lectures (in the fields of biochemistry and meteorology) [12]. Three main recommendations are made, namely:

- Give students enough time to discuss (perhaps use a timer);
- Give immediate feedback as to what constitutes reasonable responses;
- Most importantly, develop questions that stimulate higher-order thinking skills rather than simple recall.

Questioning Students

Weimer provides the following guidelines about questioning students:

- Give them time to think;
- Do not intimidate students;
- Handle wrong answers constructively;
- Get them to respond to one another [10].

As with the in-class group work, it is also necessary to ask questions that promote more than simple recall. Cannon describes three types of higher-level questions as follows:

- Understanding, translation and interpretation questions, which require students to demonstrate their comprehension;
- Evaluation questions, which require students to make some form of judgement against criteria;
- Problem-solving questions, which require students to perform analysis, synthesis or application [13].

Quizzes

Gibbs et al argue that quizzes can serve a number of useful functions. Quizzes on previous material *serve to review and rehearse* the material so that it can be more firmly established in students' memories [7]. Klionsky reports on the use of a quiz-based group learning approach in an introductory biology course of around 300 students [14]. Classes consisted of two quizzes, mini-lectures (10 minutes) and group problem-solving activities. One quiz in each class was a *reading quiz*, based on an assigned reading; while the other quiz was a *concept quiz*, based on the previous class' problem solving activities. In order to ensure student participation and completion of the assigned readings, all of the quizzes were assessable – indeed, the course assessment was based entirely on these quizzes.

The study compared student performance on particular quiz questions with performance on the same questions in mid-term examination papers in a previous, more *traditionally* taught, offering of the course. On most topics, students performed better. Student evaluations of the course and methods were also positive. Benefits noted in the study include: more frequent feedback for students and the instructor; increased participation

in class (because students were undertaking the required preparation); and greater enjoyment of the class by students and the instructor. Concerns raised in the study included: the large grading load; the use of grading as a motivating factor; and the time taken to administer quizzes within class sessions.

While there was not the flexibility to make such drastic changes to the assessment methods of this course, nor the staffing available to handle the marking load, many of the advantages of quizzes are still potentially available.

ACTIVE LECTURING ACTIVITIES

Various active learning methods described above were tried in the lecture classes given by the author. Table 1 lists the sequence of activities undertaken for several of the lectures. The activities listed are elaborated on below.

Table 1: Teaching activity sequences for lectures 7,8 and 9.

Lecture 7	Lecture 8	Lecture 9
Admin	Admin	Admin
Lecture	Response to feedback	Response to feedback
Stretch break	Lecture	Lecture
Lecture	Quick quiz	10 min. break
10 min. break	10 min. break	Lecture
Questions	Lecture	Exercise
Lecture	Stretch break	Stretch break
Exercise	Lecture	Lecture
Lecture	Exercise	10 min. break
Exercise	Lecture	Lecture
10 min. break	10 min. break	Exercise
Lecture	Lecture	Stretch break
Questions	Exercise	Lecture
Lecture	Stretch break	Lecture
Feedback	Lecture	Feedback
	Feedback	

Admin describes periods during which the lecturer talked about course administrative aspects (eg assignments) and lecture overview (eg outline, handouts and context of the lecture in the course).

The term *lecture* applies to any period of lecturer activity and student passivity. This included the lecturer talking (with and without video-projected *PowerPoint* slides); the lecturer working through examples (eg on the board); and, in some cases, the lecturer performing demonstrations (eg dynamically running software that illustrates various network concepts).

Response to feedback relates to times when, during most lectures, the first part of the lecture was used to review student feedback and questions from the previous week. Feedback forms provided space for students to ask questions (which they wanted answered in the next week's lecture) and provide feedback. Serious questions and common feedback issues were addressed at the beginning of the next week's lecture. This took the form of: simple answers to questions; reinforcement for some complex issues and additional examples for some concepts.

Exercises consisted of both individual and group work exercises. Group work exercises were used in most lectures. This usually took the form of a question or problem presented to students. In some cases, students were asked to work on the task individually first, followed by a period of discussion in groups of two or three. After this period, several groups were asked to report back to the class as a whole. The formation of groups was on an *ad hoc* basis: students were asked to discuss with their neighbours. Discussion in groups was not enforced.

Individual questions and exercises were also used in most lectures. In this context, a *question* requires thinking, recall and/or simple computation in order to be answered. An *exercise* refers to a problem that should be solved by following a particular algorithm or process. Students were presented with the exercise and/or were asked to work silently by themselves and write down the answer or solution. For questions, students were asked to volunteer their answers to the class and these were discussed or commented on by the lecturer. For exercises, the lecturer worked through the solution on the board.

Quick quizzes were used near the beginnings of lectures 2, 8 and 10. These took the form of a page of questions projected on the screen. The questions covered material from the previous week's lecture. Students were given five minutes to work through the questions individually, after which the lecturer answered the quiz. All answers and solutions were worked through on the board rather than just verbally. This was so that students had a written record of the answers and could see the process followed to arrive at the answer.

Based on the studies summarised by Bligh, a variety of *break* strategies were used to break up the three-hour class periods [2]. Breaks were used in order to maintain (or at least slow the decrease in) student alertness. The breaks used were some combination of: stand-and-stretch breaks, in which students were asked to stand up and stretch for one minute; and ten-minute breaks, in which class activities were completely halted for ten minutes.

Feedback relates to times when, at the end of each lecture, students were asked to complete a feedback questionnaire.

EVALUATION METHODOLOGY

Three evaluation methods were utilised in order to gain data about the effect of the active lecturing approach. These methods consisted of: weekly feedback questionnaires; standard university end-of-semester teaching evaluations (TEVALs); and student examination performance.

Weekly feedback questionnaires were distributed and collected for all lectures except the last, at which a TEVAL form was used instead. The feedback questionnaires utilised both Likert scales and open questions.

As TEVAL results were available for the previous offering of this course, it was decided to examine such results to determine if any significant changes were evident. Student performance in the final examination was studied to gain information about the level of understanding of students. Performance was compared with that of students in the previous year. The specific information evaluated was overall level of examination performance and performance on a specific question designed to test the synthesis of knowledge.

RESULTS

Students responded positively to most of the teaching activities, in particular, student feedback delivered the following key results:

- 85% of students agreed or strongly-agreed that quick quizzes were useful;
- 65-85% of students (varying by lecture) agreed that the questions and exercises aided understanding (see Figure 1);
- Fewer than 10% of students agreed or strongly-agreed that a more traditional lecture would be preferred;
- Over 70% of students agreed or strongly-agreed that the review of questions asked by students was useful.

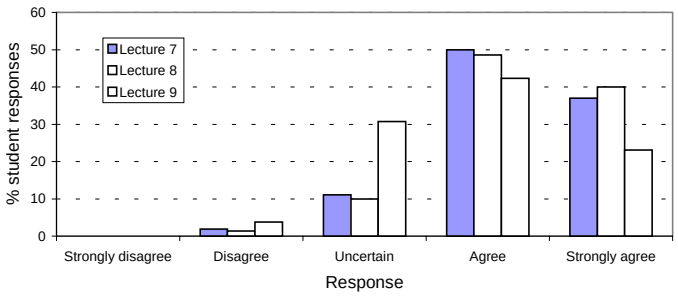

Figure 1: Distribution of student responses to the statement: *I feel the questions and exercises (today) helped me understand the material better.*

Overall, more than 85% of students agreed or strongly-agreed that the lectures aided their understanding (see Figure 2).

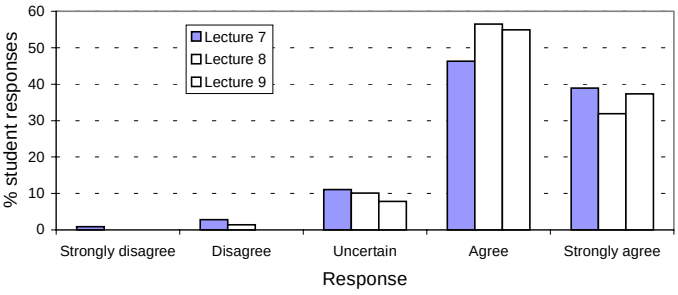

Figure 2: Distribution of student responses to the statement: *I feel the lecture aided my understanding of the material.*

A qualitative analysis of the comments received showed that quick quizzes were very favourably received. Further, exercises were generally well liked, although some students did not like the group work component; and that stretch-breaks received a mixed response in open-ended comments, but were more often mentioned as a like rather than a dislike. Official teaching evaluations showed that students rated the lecturer more highly on organisation, interesting presentation, emphasising thinking and overall effectiveness than in the previous year. Other indicators were unchanged from the previous year.

Overall examination performance improved over the previous year: the average/median mark improved from 43.9/43.5% to 47.7/47%. One question on each year's examination was specifically designed to test deeper understanding of the relationships between various protocols and layers in a TCP/IP based network, ie how well students had synthesised the knowledge from different parts of the course. The question was similar in both years; however, there was little change in the average or median performance on this question.

CONCLUSIONS

The aim of the study reported here was to make lectures in the Computer Networks I course more active learning experiences for students with the ideal aim of improving student understanding of the material. Active lecturing techniques, such as quick quizzes, group and individual exercises, reviews of student questions, and multiple breaks were incorporated into the three-hour lecture classes.

While no improvement in deep understanding of the course material was evident, student examination results did exhibit some improvement. Quantitative and qualitative feedback from students, both on specific feedback surveys and official university teaching evaluations, indicated the approaches were well received – students overwhelmingly agreed that the techniques aided their understanding of the material.

Future offerings of the course will undergo further improvements in an attempt to improve student learning. One avenue for improvement is the creation of suitable individual and group work exercises for use in class. As noted by various researchers in the field, the creation of appropriate learning tasks that emphasise high-level thinking is important, although difficult. Enhancements will also be made to the assessment aspects of the course.

REFERENCES

1. Bligh, D.A., *What's the Use of Lectures?* (3rd edn). Harmondsworth: Penguin Education (1972).
2. Bligh, D.A., *What's the Use of Lectures?* (1st US edn). San Francisco: Jossey-Bass (2000).
3. Steinert, Y. and Snell, L.S., Interactive lecturing: strategies for increasing participation in large group presentations. *Medical Teacher*, 21, **1**, 37-42 (1999).
4. Murray, R. and Brightman, J.R., Interactive teaching. *European J. of Engng. Educ.*, 21, **3**, 295-308 (1996).
5. Marbach-Ad, G. and Sokolove, P.G., Can undergraduate biology students learn to ask higher level questions. *J. Research in Science Teaching*, 37, **8**, 854-870 (2000).
6. Jenkins, A., *Active Learning in Structured Lectures*. In: Gibbs, G. and Jenkins, A. (Eds), Teaching Large Classes in Higher Education: How to Maintain Quality with Reduced Resources. London: Kogan Page, 63-77 (1992).
7. Gibbs, G., Habeshaw, S. and Habeshaw, T., *53 Interesting Things to Do in Your Lectures* (4th edn). Bristol: Technical and Educational Services Ltd (1992).
8. Biggs, J., What the student does: teaching for enhanced learning. *Higher Educ. Research and Development*, 18, **1**, 57-75 (1999).
9. Borreson, C.R., Success in introductory statistics with small groups. *College Teaching*, 38, **1**, 26-28 (1990).
10. Weimer, M., *Improving Your Classroom Teaching*. Newbury Park: Sage Publications (1993).
11. Meyers, C. and Jones, T.B., *Promoting Active Learning: Strategies for the College Classroom*. San Francisco: Jossey-Bass (1993).
12. Windschitl, M., Using small-group discussions in science lectures: a study of two professors. *College Teaching*, 47, **1**, 23 (1999).
13. Cannon, R.A., *Lecturing*. Kensington: Higher Education Research and Development Society of Australasia (1988).
14. Klionsky, D.J., Constructing knowledge in the lecture hall. *J. College Science Teaching*, 31, **4**, 246-251 (2001).