# Large-Scale Interactive Teaching via the Internet: experience with problem sessions and practical work in university courses [1]

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## Abstract

Although Internet technology and the WWW have been hailed as a panacea for education, and distance education in particular, few people are making effective use of the technology or demonstrating scalable examples, especially in terms of replacing face-to-face teaching. The Open University (UK) is one of the most successful distance teaching universities in the world and this paper presents some of the models attempted and lessons learned from large-scale Internet teaching on computing courses.

## Introduction

The World Wide Web has been heralded by the popular press as a panacea for education, and for distance education in particular. Suddenly, many conventional universities have started to offer Internet, distance-taught courses constructed from conventional lecture notes translated into HTML with a few hyperlinks. But what about *teaching*? Although such material may be a useful supplement to students studying conventionally, the demands of distance teaching extend far beyond provision of conventional course materials , and the challenges of *effective* remote education concern the quality of a student's experience. Even at a distance, students' interactions with their teachers and with other students give them perspective, place them within a community of learning, and contribute to their mastery of concepts and skills.

Face-to-face teaching and practical sessions (hereafter called 'tutorials') are seen as a focal point in distance teaching, where concepts become immediate and personal through students' interactions with both their teachers and each other. The Open University's early experiences with electronic presentation of courses have highlighted both the importance of face-to-face tutorials in distance teaching, and the challenge of replacing face-to-face tutorials with effective electronic substitutes. Providing effective tutorials outside the constraints of a given room and time has relevance beyond established distance teaching. It is part of the growing need for flexible delivery demanded:

- by multi-campus universities;
- in disciplines (like Medicine) in which expert teaching staff is scarce;
- in cases where particular expertise (e.g. technological knowledge) is concentrated in one location.

This flexibility can reduce constraints on instructors as well as students.

In translating the tutorial for Internet presentation, the priority is to preserve the immediacy of the face-to-face tutorial, despite the problems of cost, compatibility and synchronisation that apply. This paper reports experiences of 'electronic tutorials' conducted over two years as part of on-going trials presenting Computing courses via the Internet to students world-wide. It describes the university context, the technology strategy, and the synchronous and asynchronous interaction models used, and it discusses the issues observed during these trials.

## Background: the Open University context

Over 26 years, the Open University (OU) has developed a well-tuned machine for providing high-quality university education for part-time students studying at a distance. With more than 150,000

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students per year and over 120,000 degree graduates to date, it is one of the most successful distance teaching universities in the world.

All OU undergraduate teaching is through 'supported open distance learning'. The teaching and support network for students manifests itself in five distinct aspects: *teaching materials; tutorial support and assessment; counselling support; examinations* and *enquiry services*. Each student studies at home using teaching material delivered primarily by mail but using a variety of media (custom-designed books, CD-ROMs, audio tapes, video on tapes or UK-television broadcasts, laboratory materials). All teaching material is specifically designed for students working independently. This teaching is *supported* because all students are assigned a local instructor, who answers course-related questions throughout the year via telephone conversation or written correspondence, or during one of the regularly scheduled face-to-face tutorials when the students and instructor meet at in a conventional classroom setting for 1-2 hours. Throughout the course, the student is required to submit written assignments which the instructor grades and annotates, providing essential feedback.

The challenges for a large, distance teaching university include: scale; a commitment to access, despite hugely varying student circumstances; rigorous quality control which must be completed before courses are presented; and rapid feedback to a dispersed student population.

***Scale:*** With over 300 courses offered in a variety of undergraduate and post-graduate degree programs, and with as many as 8,000 students in some courses, scaling for student numbers requires considerable organisation and efficient administration.

***Access:*** The OU has no barriers to entry: the ethos of the university is to be "open and equal". Removing or minimizing the barriers to study makes 'cost', supply, and other practical considerations crucial in the use of technology. The principle of access also extends to flexibility: over 70% of students are working full-time and studying part-time, so their learning must fit around other responsibilities. In the past, people have studied with the OU from places as diverse as airplanes, cruise ships, oil rigs, or even nuclear submarines. The conventional OU study system copes well for students in these situations, and changes involving electronic communication must not disenfranchise them.

***Quality control:*** Courses are designed by a multi-disciplinary team producing custom text, software, audio cassettes, video for broadcast, and CD-ROMs. All materials must be completed and evaluated in advance; courses undergo rigorous developmental testing with a student cohort before presentation. A pre-eminent commitment to quality teaching demands that technology be made to serve education, rather than teaching chasing technology.

***Rapid feedback:*** Even though 40,000 assignments are processed per week, the students usually receive their marked assignments within a week (often within days) of the instructor submitting them. Retaining and motivating students hinges on rapid feedback, which makes communication (paper-based or otherwise) a key issue. This has been one of the barriers to the OU teaching outside the UK, where communication systems are often less reliable.

## Internet communications strategy

The commitment to access has a profound effect on how courses are designed and what may be required of students; courses may not impose an onerous burden in terms of powerful machines or expensive network access.

Although electronic communication has played a part in some OU courses for well over a decade, until recently this has been limited to a small number of courses where electronic communication was a topic in the course, and a few hundred students used one of two proprietary local conferencing systems. For the past three years, the OU has also been adopting a separate Internet-based strategy for world-wide delivery of supported distance learning courses. The university itself is effectively a very large national Internet Service Provider for its students, with local dial-in points throughout most of the UK. Nevertheless, students must pay per-minute charges for local telephone calls, and so Internet access software must provide some method of off-line working to help students minimize call charges. Over 30,000 students will make use of dial-in access to the university in 1997.

Given the current rapid developments in Internet technology, it would be tempting to develop an electronic communication strategy by assuming that students gain fast connection to the Internet via ISDN, or even a direct connection to an MBONE site--such as the one proposed by Watabe and colleagues . However, although it appears to be relatively 'future-proof', allowing advances to be built onto the present system, its current cost is prohibitive for an institution committed to access. This does not mean that the OU cannot use fast network connections to deliver high bandwidth material for teaching. It *does* require a policy of *graceful degradation* so that, as a student's personal computer specification or the speed of connection to the network decreases, the student can still receive a suitable version of the interactive component of the teaching.

The assumed ‘least common denominator’ in equipment is access to an offline e-mail facility and the ability to decode attached MIME or uuencoded files. No assumption is made about the speed of the student’s connection, which could be as low as 1200 baud. But, for the majority of OU students, the minimum hardware specification is an 8-Mb PC running Windows 3.1 with a 14.4 kbaud modem, significant numbers of students now have higher specification machines running Windows 95 and use higher-speed modems to access the OU.

All students are provided with the Netscape browser (supporting some HTML, Java, WWW file uploads, and integrated off-line e-mail), although they may use almost any WWW browser if they prefer. The university provides PPP dial-up points in the UK and POP e-mail for off-line e-mail reading, although students outside the UK are recommended to find their own Internet Service Providers with local e-mail, in order to avoid long distance telephone calls or long waiting times on Internet connections.

The experience reported here is within this Internet-based strategy: the trial presentation of Computing courses via the Internet. The first trial in 1995 involved 29 students in 9 countries studying entry-level Computing with 2 UK instructors. Its successor in 1996 has involved approximately 300 students and 22 instructors on an entry-level course, and 50 students and 2 instructors on an upper-level course, using new electronic tutorial models, improved marking tools, and more sophisticated conferencing. In 1997, over 500 students from all over the world will study a range of courses supported by at least 25 instructors.

Four main communications facilities were employed in the 1996 trial:

1. **E-mail**: Students were provided with clients for off-line mail systems (Eudora and Netscape Mail). They could send message to their instructors, to fellow students, or to groups via a mailing list facility connected by gateway to the web-based conferencing system. Many students and instructors constructed their own special-topic mailing lists. Students were required to check their e-mail regularly.

2. **Web-based conferencing**: The main asynchronous text-based conferencing system was based on the Hypernews system , with some additions to facilitate course organization, and with e-mail gateways so that it could be used to broadcast messages via e-mail as well as the conference. Students who had only e-mail access could post into the conferencing system--into the appropriate thread--by sending to a special e-mail address. Anyone in the conferencing system could elect to receive all postings to any thread or sub-thread as e-mail, so that they needn’t check for new messages; hence use of the conferencing system was effectively optional. Instructors used the conferencing system to construct tutorials in HTML and to conduct discussions in their tutorial groups.

3. **Internet Relay Chat**: Internet Relay Chat (IRC) provided a synchronous text-based discussion facility to all students with the standard equipment described.

4. **Enhanced CU-SeeMe and RealAudio**: For the audio-graphic tutorials, students in the upper-level course (all with sound capability) were provided with Enhanced CU-SeeMe software ( ), which gave them a slow-scan video image of the instructor, an IRC-like synchronous text chat facility, a shared ‘whiteboard’, and limited two-way live audio. For better audio quality, students were also provided with RealAudio software ( ).

## What do students want from tutorials?

Distance students often report a feeling of isolation when studying because of their lack of contact with an instructor or other students. The emphasis on electronic tutorials arises from previous experiences of electronic presentation, as well as from earlier analyses of what students derive from face-to-face tutorials. The benefit to students is only partly academic; the tutorial is an important social focus that allows students to build relationships with their instructors and other students. Students report that tutorials provide:

1. a chance to meet the instructor who is marking their work;

2. demonstrations of expert behaviour, worked examples, an alternative look at the course material;

3. structure; milestones; incentives; an indication of the appropriate emphasis or degree of importance for various topics in the syllabus;

4. pointers about the kind of problems they will face in assignments;

5. learning from other students' questions, mistakes, insights;

6. reassurance that the student is making appropriate progress, and that the student's progress is comparable to that of other students;

7. social contact with other students (Tutorials are crucial in establishing student networks, etc.)

OU statistics over years indicate that students who attend tutorials tend to perform better than those who don't. However, poor or less-confident students tend not to attend tutorials, and nor do busy or remote students or those unable to travel. For students who cannot attend face-to-face sessions, electronic communication can help overcome many of the problems faced by distance learners .

## What is a typical face-to-face tutorial?

In the broadest characterization, face-to-face tutorials tend to have two main parts:

1. a diagnostic component, in which instructors clarify where students are with respect to coursework and answer any questions, and in which they reflect on a previous assignment, giving attention to points of difficulty;

2. a lecture or problem-solving component, in which instructors present examples and issues and elicit discussion, or in which students solve and discuss problems.

Instructors are given a 'free hand' in running their tutorials, but the 'typical' tutorials they report fall into three general formats:

1. open question and discussion sessions which are student-centred.

2. lecture-type sessions which provide an augmented view of the course material, either through additional explanation or worked examples.

3. workshop-type, problem-solving or practical sessions in which students work individually or in small groups on problems of varying difficulty. Interaction and discussion are emphasised.

## Models attempted

At the start of the term, several electronic tutorial models were suggested to the instructors; the suggested models tried to accommodate both the constraints and the opportunities inherent in electronic communication in order to provide valuable tutorial functions with the simplest effective technology--hence the emphasis on structured, asynchronous tutorials. Among the suggested models were the 'asynchronous problem-solving and discussion' model and the 'asynchronous group working' model which appear in . The instructors adjusted those models and invented new ones to suit their own teaching. Tables 1- 3 present a distillation of those experiences, grouped by mode (asynchronous, mixed, and synchronous) and ordered by the number of examples.

**Table 1: asynchronous tutorials**

| no. | description |
|---|---|
| 30 | **asynchronous problem-solving and discussion**<br>1. timetable is announced (typically either 2-3 days or 7-10 days)<br>2. problems are set, often in stages; these may be programming problems, questions about program fragments, design questions, etc.<br>3. students submit solutions (either directly, or anonymized), discuss each other's responses, and ask questions (either on conference or via email)<br>4. instructor contributes to the discussion, guiding the work<br>5. instructor reviews important points and sends 'model' answers, sometimes only by request<br><br>*variations:*<br>**asynchronous topic discussion**:<br>students discuss issues or topics, often responding to provocative statements, rather than solving aspects of programming problems.<br><br>**cumulative asynchronous problem solving**:<br>e.g., "asked for volunteers...persuaded students to circulate efforts...shared later tasks...to combine for a big solution to a modularized problem"<br><br>**revision tutorial**:<br>former examination questions are given, discussed, and solved collectively; a post-mortem is provided by the instructor<br><br>[1 - 10 active participants; often as many 'lurkers'] |
| 8 | **the individual tutorial**<br>1. problems are announced (either on conference or via email); these may be programming problems, questions about program fragments, open-ended questions, etc.<br>2. students reply and ask questions via email to instructor<br>3. instructor makes individual replies; no general discussion<br><br>[1 - 7 participants] |

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|---|---|
| 4 | **asynchronous group work**<br>1. problems are set; these are usually based on a scenario about developing a piece of ‘real world’ software<br>2. groups are set, either by subscription or by problem choice (students must declare themselves in advance)<br>3. groups collaborate and agree on the solution which is submitted for general discussion<br>4. instructor keeps tabs on groups and comments or guides as necessary<br>5. instructor reviews important points and sends ‘model’ answers, sometimes only by request<br>*variation:*<br>**cumulative asynchronous group** work, with staged weekly sub-tasks contributing to a longer-term solution.<br>[4 - 8 participants] |
| 4 | **virtual office hours**:<br>instructor sets fixed period when instructor will be reading email and responding immediately; students may ask questions for quick response |
| 3-4 | **Q&A repository**:<br>Instructor presents on Web a collection of:<br>◀ questions, discussion and answers from email with students;<br>◀ ‘thought points’ to get the students thinking beyond the course material<br>◀ questions followed by worked examples |
| 3; wide reuse | **stand-alone tutorial**:<br>structured hypertext presented on Web: sequences of discussion, problems, answers covering a series of topics |
| 3 | **fetch-and-respond**:<br>students are expected to read material or collect information or examples off-line which they report and discuss via email or conference<br>[2 - 8 participants] |
| 3 | **read-and-respond**:<br>instructor posts notes or worked examples and asks for responses and discussion |
| 2 | **role play for collective programming**<br>1. students subscribe<br>2. students bid for or are given tasks which contribute to a modularized group project or at least to group discussion<br>3. instructor summarizes<br>*variation:*<br>**cumulative role play**, with stages over a month |
| 2 | “**open mentoring**”<br>question-asking service, student-driven, with answers broadcast to all students |

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|---|---|
| 2 | **the continuous tutorial**:<br>instructor-driven:<br>1. problems are set on a regular basis, with discussion and then post-mortem;<br>2. new problems are set when students provide answers to the current ones;<br>3. programming problems are inter-mixed with discussions on programming topics or conundrums<br>[1 example has 14 rounds; another has 4] |
| 1 | **the Web treasure hunt**:<br>students are expected to solve a step in order to get the instructions for the next one;<br>steps are distributed in different web locations |

**Table 2: Mixed-mode tutorials**

| no. | description |
|---|---|
| 2 | **mixed-mode tutorial**:<br>1. timetable, introductory material and problems posted<br>2. time for asynchronous email discussion<br>3. Q&A accumulating during tutorial are assembled on Web<br>4. IRC on a specified date<br>5. IRC log distributed to all students via email<br>[4 - 6 participants] |

**Table 3: Synchronous tutorials**

| no. | description |
|---|---|
| 5 | **IRC tutorial**<br>'Interactive Relay Chat': synchronous text-based interaction via the Internet;<br>instructor-led discussion, typically about an hour;<br>problem solving, discussion of topics, or 'chalk-and-talk';<br>a text file of the discussion can be saved<br>[4 - 6 participants] |
| 2 | **audio-graphic tutorial**<br>1. tutorial materials distributed in advance<br>2. quasi-real-time audio and video from instructor;<br>pre-prepared materials (both text and graphics) plus synchronous annotation displayed in workspace shared with students;<br>3. shared 'chat' space for textual submissions from students<br>*variations:*<br>**'chalk-and-talk'**-style presentation;<br>discussion of topics<br>[4-5 participants in UK and North America] |

| | |
|---|---|
| 1 | **MUD tutorial**<br>synchronous text with added expressive elements<br>[3-4 participants in UK and North America] |

## Issues:

**duration of tutorials:** Preliminary results suggested that deadlines and milestones are important in electronic tutorials, and so early asynchronous tutorials were held over 2-3 days, often a weekend. However, many instructors reported that 2-3 days just wasn't long enough, and that they had more success with the week-long tutorial. The advantages of the longer period include:

- time for students to reflect on or to re-try exercises
- time for busy students to 'look in' (hence better 'catchment')
- the opportunity to tackle problems of realistic size, rather than mini-problems -- partly because the tutorials can be cumulative, and a momentum can be created.

**tutorial group size:** There is no clear indication of optimum group size. Active participation in the tutorials was low, but a good interaction could be achieved with 3-4 students, and instructors remarked that many students were known to 'lurk'. In general, the pattern of participation appears to have followed the pattern observed in other conferencing studies: 1/3 are active participants; 1/3 are occasional participants; 1/3 lurk when they have time.

**instructor teams:** Those instructors who were able to collaborate with one or more other instructors seem to have benefitted, both by sharing the load (and thereby giving students better coverage) and by having the contact: instructors appear to get some of the enthusiasm from each other that they miss from face-to-face tutorials. Some of the best reports come from combined-group tutorials.

**participation:** Participation appeared low, but several instructors remarked that it was comparable to attendance at face-to-face tutorials. Instructors and students both remarked that electronic tutorials reached students unable to attend face-to-face tutorials.

'Attendance' at tutorials tended to drop off, but was revived by alternative tutorial strategies (e.g., role play) and by other mechanisms (e.g., requiring students to register in order to participate).

**lurkers:** Instructors consider it an advantage that some students can lurk, but lurkers pose a disadvantage for instructors: less feedback. In face-to-face tutoring, there is still some interaction with passive students, and instructors cater for a sort of 'passive absorption'. In electronic tutoring, the lurkers are 'invisible' and the instructor may feel that few students are attending. Many instructors reported that nearly all of the students in their groups read the tutorials, even if they didn't contribute: *"Even those students too shy to join in later said they followed the exchange of emails and said they found it useful."*

**interaction:** Several instructors reported that they get *more* interaction in their electronic tutorials than in their face-to-face tutorials. However, several instructors reported that they couldn't raise any interaction at all. About interaction, both instructor and student experience are divided -- some successes, some disasters. What evidence we have suggests that including some synchronous device like IRC is likely to increase the satisfaction with interaction: *"I think the IRC experiment was successful in that students enjoyed the interaction together"*. Most electronic students do report that their rapport with their instructor has developed during the course (although this varies among instructors). Instructors report that students are adapting to the medium, too: *"...students are getting used to the idea of sending comments or queries with their messages..."*

**jokes:** It may be worth noting that the instructors' most common answer to *"What can't you reproduce in electronic tutorials"* is *"the jokes"*. But in the 'successful interaction' groups, there is plenty of humour.

**instructor buzz:** Instructors get value from face-to-face tutorials, too, which many lose in electronic tuition: a satisfying 'buzz' from the interaction with the students. Some do not view electronic tutorials as enjoyable. Contributing to this perception are a lower rate of interaction and a lack of feedback -- instructors do not get immediate reassurance that the students are understanding them, the interaction is less intense, they cannot count heads, etc.

**preparation and quality of teaching:** The instructors who participated in the 1996 trial were all experienced, highly-regarded instructors. They already had a repertoire of effective practice in face-to-face tutorials; and they already had material in hand. What success there was is attributable to the excellence of the teaching: the careful preparation, the nature of the setting and structure, the guidance, the quality of interaction, the ability to re-phrase explanations, appropriate milestones, time invested, and so on--including the ability of these instructors to adapt to the new medium. But the failures are *not* attributable to the instructors; in many cases, the same model -- even the same material -- had been a success in another group.

With feedback uncertain, instructors must be prepared to hold a tutorial 'in a vacuum'. Explanations previously offered on-the-fly from notes must be presented in coherent prose, and that prose becomes available for re-reading by the students. More preparation is required, at least initially, than for face-to-face tutorials.

**the 'continuous' tutorial:** Several instructors proposed (and to an extent implemented) the 'continuous' tutorial, with some problem or question current nearly all the time, but with topics rolling over on a regular basis. Obviously, this requires more instructor time, and it must be monitored and revitalized if it flags.

**scope of material:** Some instructors claim that they cover *more* material in electronic tutorials, and that they can tackle more realistic problems, in part because the tutorials last longer, and in part because they can be cumulative. However, several instructors have expressed concern that they aren't really able to present alternative forms of information; whatever they do is largely in text, rather than through more direct interaction: *"We can't stand up and wave our hands about."*

**group work:** Although several of the group work tutorials were considered successful, instructors found it difficult to initiate group working (as evidenced by the few examples), and there is clearly a need for better mechanisms for group working. Two ingredients of the successful groups were 'registration', so that students had to sign up for the tutorial in advance, and role playing.

**replayable material:** One benefit of electronic tutorials is that most are automatically recorded and can be reviewed 'off-line' either by participants or non-participants. This was an advantage in off-setting some of the problems; for example, difficulties in synchronising a geographically-dispersed tutorial group are balanced by opportunities for automatic recording and replay of interactions. At least one of the instructors who ran IRC tutorials distributed the log files to all students in that tutorial group.

**diagnosis:** In conventional distance teaching, diagnosis is concentrated in the face-to-face tutorial sessions. In Internet teaching, diagnosis has become decoupled from the tutorial, so that diagnosis is a continuous activity on email. Some instructors introduced regular diagnostic mechanisms, such as a fortnightly query to students on their understanding of some aspect of the course, or just a question about whether they were comfortable with the material. Sometimes asynchronous communication can be disadvantageous when trying to diagnose a particular student problem. Instructors have remarked that students show a reluctance to commit things to the record, and hence they are concerned that problems may remain unexpressed.

**demands on students:** Instructors wondered about the demands on students: *"I'm worried that we're loading the students too heavily."*-- requiring more time and effort from each student. Asynchronous collaboration with other students involves longer elapsed time, whereas collaboration in a conventional tutorial happens within a fixed couple of hours. And 'passive absorption' is less obviously available: *"You want an element of 'sit back and take this in' and it will help you--I find that hard to put into an electronic tutorial."*

**supporting materials:** Experience emphasizes the additional need for supporting materials: post-mortems, examples, structured reviews--material that reiterates, re-illustrates, and emphasises the structure of course materials. One instructor instituted the 'tutorial checklist': a list of what the student should understand after the tutorial.

## Lessons:

Opinion on electronic tutorials is divided: some groups work, and some do not. On the basis of these trials, we cannot attribute failure to any particular model, nor can we attribute it to any particular instructor. We can, however, list some factors we believe contribute to success, whatever the model.

The key seems to lie in bringing the social interaction alive. Some instructors and students seem to achieve this through asynchronous text, whereas others may need a 'social starter': a face-to-face tutorial, IRC, video -- some way of conveying personalities within the group. Humour matters: most instructors complain that they don't get a chance to joke, but the successful tutorials had plenty of humour in them. Humour is an important enlivener.

Students are surprisingly resilient, especially when the choice is between electronic tutorials and nothing. Students adapt to the technology, the protocols, the limitations, the possibilities.

Structure matters: most of the successful tutorials were presented in stages, with clear tasks and milestones, and a clear review of the material covered. In the first presentation, this entails considerable preparation; but in subsequent presentations, or within a different structure of team teaching, that preparation could 'pay off' in re-use.

At this level of technology, electronic tutorials are no substitute for face-to-face tutorials, although they clearly have value and tremendous potential. And yet the potential must be realized at this sort of level--where technology is inexpensive and available--so that technology makes education accessible rather than exclusive.

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