Programming practical work and problem sessions via the Internet

Marian Petre and Blaine Price
Centre for Informatics Education Research, Computing Department, Open University, UK
m.petre@open.ac.uk, b.a.price@open.ac.uk

Abstract

Can we find effective substitutes for face-to-face teaching, especially for student-led problem sessions and collaborative practical work? 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. This paper presents some models attempted and lessons learned in large-scale Internet teaching on Computing courses.

Introduction

The World Wide Web has been heralded by the popular press [1] 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 [2], and the challenges of effective remote education concern the quality of a student's experience: we must find ways of handling practical work and discussions that gives students the benefits—social contact, perspective, motivation, reassurance of belonging to a community of learning.

Face-to-face teaching and practical sessions (hereafter called 'tutorials') are a focal point in distance teaching, where students are given a chance to see expert behaviour, and where concepts become immediate and personal through students' interactions with both their teachers and each other. Even at a distance, such interactions contribute to students' mastery of concepts and skills. The benefit to students is only partly academic; the tutorial is an important social and emotional focus that gives students a chance to compare themselves in terms of performance, problems, and priorities—and a chance to benefit from other students' questions, mistakes, and insights [3].

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;
- where expert teaching staff is scarce;
- in cases where particular expertise is concentrated in one location.

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 synchronous and asynchronous interaction models used and the issues observed during these trials.

Background and setting

University commitments to quality and open access, and attention to large-scale delivery (on the order of thousands of students per course), shape the strategies employed in these trials.

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. This does not mean that the university 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 first trial in 1995 involved 29 students in 9 countries studying entry-level Computing with 2 UK instructors. Its successor in 1996 has involved some 250 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 world-wide will study a range of courses supported by at least 25 instructors.

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. The speed of the student's connection could be as low as 1200 baud. For the majority of students, the minimum hardware specification is an 8-Mb PC running Windows 3.1 with a 14.4 kbaud modem, although many have higher specification machines running Windows 95 and use higher-speed modems.

ITiCSE '97 Working Group Reports and Supplemental Proceedings
© 1997 ACM 1-58113-012-0/97/0010...$3.50

Four main communications facilities were used in the 1996 trial:

i. electronic mail;

ii. Web-based conferencing with e-mail gateways so that it could be used to broadcast messages via e-mail as well as the conference;

iii. Internet Relay Chat (IRC), providing a synchronous, text-based, discussion facility;

iv. Enhanced CU-SeeMe and RealAudio, giving a slow-scan video image of the instructor, an IRC-like synchronous text chat facility, a shared 'whiteboard', and limited two-way live audio [4].

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 students' progress with respect to coursework, answer questions, and reflect on a previous assignment;
2. a *lecture or problem-solving* component, in which instructors elicit discussion on examples and issues, 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, student-centered, question/discussion sessions;
2. lecture sessions which provide an augmented view of the course material through additional explanation or worked examples;
3. workshop, problem-solving or practical sessions in which students work on problems individually or in small groups. Interaction & discussion are emphasised.

Models attempted

At the start of the term, electronic tutorial models were suggested which 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 [5]. The instructors adjusted those models and invented new ones to suit their own teaching. The following sections present a distillation of those experiences, grouped by mode (asynchronous, mixed, and synchronous) and ordered by the number of examples.

Asynchronous tutorials

Asynchronous problem-solving and discussion (30 instances; 1-10 active participants; often as many 'lurkers')

1. Timetable is announced (2-3 days or 7-10 days);
2. problems are set, often in stages: programming problems, questions about program fragments, design questions, issues or topics for discussion, etc.;
3. students submit solutions (either directly, or anonymized), discuss each other's responses, and ask questions (either on conference or via email);
4. instructor contributes to and guides the discussion;
5. instructor reviews important points and sends 'model' answers, sometimes only by request.

The individual tutorial (8 instances; 1-7 participants)

1. Problems are announced; these may be programming problems, questions about program fragments, open-ended questions, etc.;
2. students reply and ask questions via email to instructor;
3. instructor makes individual replies; no general discussion.

Fetch-and-respond (6 instances; 2- 8 participants)
Students are expected to read material or collect information or examples off-line which they report and discuss via email or conference.

Asynchronous group work (4 instances; 4-8 participants); may be cumulative, with staged weekly sub-tasks contributing to a longer-term solution.

1. Problems are set; these are usually based on a scenario about developing 'real world' software;
2. groups are set, either by subscription or by problem choice (students must declare themselves in advance);
3. groups collaborate and agree on the solution which is submitted for general discussion;
4. instructor keeps tabs on groups and comments or guides as necessary;
5. instructor reviews important points and sends 'model' answers, sometimes only by request.

Q&A repository (3- 4 instances)
Instructor presents on Web a collection of:

- questions, discussion and answers from email with students;
- 'thought points' to get the students thinking beyond the course material;
- questions followed by worked examples.

Stand-alone tutorial (3 instances, wide re-use)
Structured hypertext presented on Web: sequences of discussion, problems, answers covering a series of topics.

Role play for collective programming, often cumulative over a month (2 instances)

1. Students subscribe;
2. students bid for or are given tasks which contribute to a modularized group project;
3. instructor summarizes.

"Open mentoring" (2 instances)
Question-asking service, student-driven, with answers broadcast to all students.

The continuous tutorial (2 instances; one with 1 14 rounds; another with 4)

1. Problems are set on a regular basis, with discussion and then post-mortem;
2. new problems are set when students provide answers to the current ones;

3. programming problems are inter-mixed with discussions on programming topics or conundrums.

Mixed-mode tutorials

Mixed-mode tutorial (2 instances; 4-6 participants)
1. Timetable, introductory material and problems are posted;
2. time is allowed for asynchronous email discussion;
3. Q&A accumulating during tutorial are put on Web;
4. IRC on a specified date;
5. IRC log distributed to all participants.

Synchronous tutorials

IRC tutorial (5 instances; 4- 6 participants)
'Interactive Relay Chat': synchronous text-based interaction via the Internet; instructor-led discussion, typically lasting about an hour; problem solving, discussion of topics, or 'chalk-and-talk'; a text file of the discussion can be saved.

Audio-graphic tutorial (2 instances; 4-5 participants)
1. Tutorial materials distributed in advance;
2. quasi-real-time audio and video from instructor; pre-prepared materials (both text and graphics) plus synchronous annotation displayed in workspace shared with students;
3. shared 'chat' space for students textual submissions.

MUD tutorial (1 instance; 3-4 participants)
Synchronous text with added expressive elements.

Issues:

Duration of tutorials: Early asynchronous tutorials were held over 2-3 days. However, many instructors reported advantages of week-long tutorials:

- time for students to reflect on or to re-try exercises
- better 'catchment' of busy students
- 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. Good interaction could be achieved with 3-4 students, but most students 'lurked'. In general, the pattern of participation is the familiar one: 1/3 active participants; 1/3 occasional; 1/3 lurkers.

Lurkers: Instructors consider it an advantage that some students can lurk—and most do—but lurkers pose a disadvantage for instructors: less feedback. Instructors get a satisfying 'buzz' from face-to-face interaction with students, which many lose in electronic tuition. In face-to-face tutoring, there is still some interaction with passive students, and instructors cater for a sort of 'passive absorption'.

Instructor teams: Those instructors who were able to collaborate with other instructors benefited, both by sharing the load (and thereby giving students better coverage) and by having contact: instructors appear to get some of the enthusiasm from each other that they miss from face-to-face tutorials. Some of the most favourable reports came from combined-group tutorials.

Interaction: Several instructors reported that they get *more* interaction in their electronic tutorials than in their face-to-face tutorials. However, several reported that they couldn't raise any interaction at all. Both instructor and student experience are divided, although most students report that their rapport with their instructor has developed during the course. Including some synchronous device like IRC is likely to increase the satisfaction with interaction. Instructors report that students are adapting to the medium: *"...students are getting used to the idea of sending comments or queries with their messages..."*

Jokes: 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.

Preparation and quality of teaching: The instructors who participated in the 1996 trial were all experienced, highly-regarded instructors. Any success is attributable to the excellence of the teaching: careful preparation, effective setting and structure, guidance, quality of interaction, re-phrasing of explanations, appropriate milestones, 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 the 'continuous' tutorial, with some problem or question current nearly all the time, but with topics 'rolling over' on a regular basis. This requires more instructor time and must be 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, some instructors have expressed concern that they aren't really able to present alternative forms of information; whatever they do is largely in text: *"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, and there is clearly a need for better mechanisms for group working. Two ingredients of the successful groups were 'registration', requiring students 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.

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, becoming a continuous activity on email. Instructors found diagnosis of programming problems eased by electronic communication. Some introduced regular diagnostic mechanisms, such as a fortnightly query to students on their understanding of some aspect of the course.

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 to any particular instructor. We can, however, list some factors we believe contribute to success.

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

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.

Acknowledgements

The authors acknowledge the contributions of the participating instructors and students, Paula Cole who assisted in data handling and coding, Jenny Bull and the Assignment Handling Office staff, the Assignment Records Office staff, the Office for Technology Development, and the rest of the MZX team (Linda Carswell, Barbara Poniatowska, Mike Richards, Pete Thomas, Debra Thompson).

References

1. Reinhardt, A. New Ways to Learn. *Byte*, 1995. **20**(3): pp. 55-71.

2. Mason, R. and A. Kaye., eds. *Mindweave communication, computers and distance education.* 1989, Pergamon Press: Oxford.

3. Alexander, G. Designing Human Interfaces to Promote Collaborative Learning, in *Collaborative Learning Through Conferencing: The Najaden Papers*, A.R. Kaye, Editor. 1992, Springer-Verlag: New York.

4. Petre, M., Thomas, P., Price, B. Report on Live Synchronous audio-graphic tutorials. Open University: Milton Keynes, UK. Technical Report 96/10, October 1996.

5. Thomas, P., Carswell, L., Emms, J., Petre, M., Poniatowska, B., Price, B. Distance education over the Internet, *ACM SIGCSE Bulletin*, **28** (Special Issue: Proceedings of ITiCSE '96 – SIGCSE/SIGCUE Conference on Introducing Technology into Computer Science Education), 1996, 147-149.