Innovations in large-scale supported distance teaching: transformation for the Internet, not just translation

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Abstract *This paper reports on large-scale trials of Internet-based university-level distance teaching. The use of technology, and more specifically the Internet, has been an important advance for distance education. However, simply translating material from familiar media into electronic form is rarely productive — and is certainly inadequate for supported distance education, which aims to engage the student in a 'community of learning'. The value Internet technology brings to distance education lies not in direct translation from other media but in transformation of support mechanisms to exploit its potential range. The paper begins by considering how instruction and support functions can be served and potentially enhanced by an Internet-based structure. It considers which changes in culture help to preserve or improve teaching quality while adapting to screen-based and often asynchronous interactions. It discusses our trials of mechanisms for interactions among students and instructors; assignment marking using an electronic marking tool; electronic assignment handling; synchronous and asynchronous Internet-based problem sessions; and automatic student registration. The paper will summarize qualitative and quantitative findings of an extensive evaluation involving several hundred students over three courses and considering learning, student experience, assignment marking, problem sessions, scalability, and integration into existing administrative structures. It will highlight both costs and gains of using the Internet to transform the distance learning environment for those associated with it: students, instructors, administrators, institution.*

1. Introduction: transformation, not translation

The use of technology, and more specifically the Internet, has been an important advance for distance education. The Internet has the potential to meet students' changing social and educational needs — in particular the need to choose their own time, place, and style of study. Universities respond to societal trends, and it is natural that they should follow the trend to use technology [1]. "Universities, like other organizations, are having to re-examine their ways of working, stimulated by developments towards 'an information superhighway' and the ease of accessibility to non-discursive global information resources" [9]. Educators are looking to technology to solve many of their problems — including increasing student:staff ratios and diminishing funding — while at the same time seeking to improve their teaching to provide a better student experience [7, 8, 10].

Yet innovation comes at some cost, and knock-on effects may include increased demands on staff time, complication of the supporting administrative system, and additional overheads for students [3]. Many institutions are converting lecture notes or other paper-based materials to HTML for the world-wide web, but, with little support provided for the student, the gains are minimal. Simply translating material from familiar media into electronic form is rarely productive — and is certainly inadequate for *supported* distance education, which aims to engage the student in a 'community of learning'. If we hope to *improve* rather than *translate*, we must understand the whole teaching and support process through a critical examination of its functions. What the popular enthusiasm for the Internet and the superficial translation exercises tend to overlook are the fundamental questions:

- whether technology's effect on the learning it is meant to support is constructive, rather than obstructive; and
- whether the benefits offered outweigh the costs involved.

For two years, we have been developing a learning environment to support the whole instruction process, encompassing students, tutors, staff support, and administration. The thrust of the work is the integration of support systems to improve the teaching process holistically. We have investigated mechanisms for:

- interactions among students and tutors;
- assignment marking using an electronic marking tool;
- electronic assignment handling;
- synchronous and asynchronous Internet-based problem sessions;
- automatic student registration; and
- electronic examination.

The systems have been tried on an entry-level and an upper-level Computing course, involving approximately 350 students and 23 experienced tutors in 1996. The trials are being repeated in 1997 with some 500 students.

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learning, student experience, assignment marking, problem sessions, scalability, and integration into existing administrative structures. It considers which changes in culture help to preserve or improve teaching quality while adapting to screen-based and often asynchronous interactions. It highlights both costs and gains of using the Internet to transform the distance learning environment for those associated with it: students, tutors, administrators, institution.

2. Supported distance education at the Open University

The Open University (OU), which teaches around 150,000 students at a distance, has developed (over more than 25 years) a well-tuned machine for providing high-quality university education for part-time students studying at a distance.

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 materials delivered primarily by post but using a variety of media. For each course, the student is allocated a local tutor who teaches via correspondence and helps with queries related to the academic materials. The tutor is normally contacted by telephone or post. Students may also attend local, face-to-face tutorials run by their tutors, and they may choose to form 'self-help groups' with other students.

The mainstay of teaching is the tutor-marked assignment (TMA). Throughout the course, the student is required to submit written assignments, which the tutor grades and which the tutor annotates freely, providing essential feedback. The TMA has two roles: summative and formative, for assessing student progress and as a teaching tool for taking remedial action. Tutor notes, including a marking scheme, are provided in order to ensure assessment quality, and marked TMAs are monitored regularly for consistency and marking quality.

The pre-eminent commitments for the OU are to access and quality:

Access: The OU has no barriers to entry: the ethos of the university is to be "open and equal". Admission is on a first-come-first-served basis, and all entry-level courses are designed to allow students with little formal background to reach university entrance level quickly. Yet students can still be disadvantaged: personal, local, or geographical constraints may restrict individual students' access to face-to-face sessions or telephone contact with the tutor. As a result, many students rely solely on the printed material and TMA correspondence with their tutors.

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. Quality must also be maintained in presentation. On a course with 5,000 students (e.g., an introductory Computing course), some 200 part-time tutors' work must be co-ordinated and sustained at uniform standard.

The key challenges for a large, distance teaching university are scale and rapid feedback to a dispersed student population.

Scale: In some courses in the Open University, there are as many as 8,000 students, and the total number of students per year exceeds 150,000.

Rapid feedback: Even though 40,000 assignments are processed per week, the efficiency of the U.K. postal service means that the students usually receive their marked assignments within a week (often within days) of the tutor 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.

Electronic communication is hoped to have significant impact in each of these four areas: overcoming access barriers, providing flexibility and responsiveness in accommodating various student circumstances, providing automatic records and checks against minor errors, and providing efficient tools for administrators and over-stretched tutors. But an electronic system must prove itself secure, robust, scalable, and affordable.

3. The Internet presentation trials: mechanisms and evaluation

Our solutions must observe the OU ethos of begin "open and equal" with respect to
technology access, both in the UK and abroad. Hence the backbone of our technology is plain-text Internet e-mail, which can cater for almost any student, regardless of the speed of the network connection or software available. A number of mechanisms have been developed:

- a Web-based, automatic registration system (see http://mzx.open.ac.uk);
- electronic examination using encrypted examination papers downloaded via the Web at strictly supervised examination centres at appointed times;
- an electronic assignment handling system, including electronic assignment submission, a marking tool (with a component for monitoring), and automatic verification and record-keeping; and
- conferences and Web resources.

Only the latter two will be discussed in this paper.

Electronic assignment handling system

The university has well-established procedures for grading paper assignments which must be interpreted for electronic assignments. The lynch pin is a standard multi-part form

which accompanies assignments and accumulates details from student, tutor, administrators and monitor in turn. Students submit assignments to their tutor, who notes grades and comments both on the cover form and on the assignment itself. The assignment is marked in conformance to a scheme specified by the Examination and Assessment Board which also sets the assignments and provides 'post-mortem' discussions of them. The tutor then sends the assignment to the central Assignment Handling Office which enters all the information into a database, verifies details, and returns the assignment to the student. The paper system requires the TMA to be posted three times and potentially to be photocopied at more than one stage. If any of the details is incorrect, the tutor is contacted for corrections; this happens in about 5% of assignments (half a million assignments a year).

The current electronic system is unix-based, involving a central collection of databases, and with supporting software written in Perl and Java.

i) ***Student TMA submission:*** Students send their assignments electronically to a central automatic handler which verifies details, sends a numbered receipt, logs a copy of the assignment, and sends a copy to the tutor with a special data file.

ii) ***Tutor TMA receipt and marking:*** The tutor uses a forms-based WWW interface to collect assignments, which are down-loaded to the tutor's machine. The tutor uses Microsoft Word 6/7 with a template developed for the course to mark the assignment, automatically converting the student document from its original format to the native format. The template uses the data file to complete an electronic version of the multi-part form with all of the details except the grades and the tutor's comments. The template has a number of built-in tools to aid marking. The tutor can delete or insert text in any font or format anywhere in the document; inserted text appears underlined in blue, and deleted text is displayed with a red strike-through. Check marks and crosses can be inserted with a keystroke. Annotations can be added which provide a kind of hypertext comment (which appears in a separate frame on screen or as end-notes if the document is printed). Marks for questions are entered using a dialog box which automatically verifies that the grade is in the correct range for that question, copies the number onto the cover form, and adds up the marks. The drawing tools included in the word processor are available, so that freehand drawings are possible.

iii) ***Tutor TMA submission:*** The tutor returns the marked assignment to another automated handler which records the grades in the university system, sends the tutor a receipt, and e-mails the assignment back to the student. Since the form filling and addition tasks are performed automatically, administrative errors of the type cited above do not occur. Students have been provided with a viewer application to browse and navigate through the returned document or print hardcopy. It should be noted that, although the marking tool is multi-platform, most students and tutors have low-specification PCs.

iv) ***Monitoring:*** The marking tool includes a comparable template for the monitor (a senior member of staff who reviews tutors' performance) which allows the monitor to add typographically distinct comments or corrections to both the multi-part form and the marked assignment.

Conferences and Web resources

Our conferencing system allows one-to-many and many-to-many communication. Its interface is a forms-based WWW system which supports membership access control, sub-grouping, user-selected e-mail notification of any posting, and embedded HTML with images and 'hot links' which mean that, when a posting refers to another point on the WWW containing additional teaching material or software to be downloaded, the student need only click on the link to go directly there. As course material is moved onto the WWW, tutors will be able to provide answers or present tutorials which refer to course material with live hyper links, rather than static references. The notification facility supports a 'stop press' conference to which all members of the course are automatically subscribed, giving them (a) an automatically-sent e-mail copy of every posting, and (b) read-only access to a reference copy of the announcement. Thus, those students whose access is through a slow Internet connection or simple e-mail are not disadvantaged. Other conferences are available for both social and work-related discussions; most are for 20 to 50 students to keep discussions manageable. Students with e-mail only access can treat these conferences as mailing lists and remain full participants. Tutors have Web access to a database of tutorial material, examples, and frequently-asked-question sets.

4. Evaluation and lessons

Considerable data, both qualitative and quantitative, has been collected to support well-founded comparisons of conventional and electronic delivery: the project has access to all examination results, about 3,000 marked assignments, some 1,000 questionnaires from both students and tutors, all conferences and most electronic mail, tutor records of their interactions with students, and records of de-briefing meetings with tutors. Some participating tutors have combined electronic and conventional tutorial groups; others have all-electronic or all-conventional groups. This has allowed us to make comparisons between delivery methods and to examine the impact which individual differences in tutor style have on resource usage and on learning effects.

Detailed reports of specific analyses are presented elsewhere [10, 2, 6, 4]. Presented here are some of the main observations, including some examples illustrating the fundamental lesson of the trials: that it isn't enough merely to translate existing *practice*; the underlying *functions* must

be served through strategies that exploit the strengths of the medium.

Learning and the students' experience

Performance indicators (TMAs and examination results) for all of the students, both conventional and Internet, were compared statistically. Questionnaire responses, TMAs and examination results were analysed for 75 students (45 conventional; 30 Internet) on the entry-level course in 1996. The aim was primarily to assess the impact of the delivery medium and secondarily to identify factors related to learning: indicators of attitudes, learning styles, and performance for each group of students were compared statistically [2]. The detailed information gleaned in the background questionnaires provides justification for generalising from this self-selected sample, although the study will be repeated with a new student cohort in 1997. The nature of the detailed assignment marking and quality-controlled examination mechanisms used in the OU arguably make it reasonable to use grades as indicators of learning.

Performance is comparable

Performance between the Internet and conventional student cohorts was statistically comparable; in broad terms, learning appears unimpaired by Internet presentation. No learning style was found to pre-dispose students to better or worse performance using a particular communication medium. There was a significant correlation of attributes such as the student's perception of his or her ability, confidence, and previous experience to performance. It appears that the student's self-image and expectations have the greater influence on learning outcomes.

Interaction

Students reported that their rapport with their tutor developed, and many reported that contact was freer via e-mail than it would have been by telephone. Some tutors reported that they had more interaction with their electronic students, especially the weaker ones, who find electronic communication less inhibiting. The diagnostic function of face-to-face sessions shifted away from the electronic tutorials to individual e-mail interaction. On the other hand, more Internet than conventional students were disappointed in their fellow students, and most felt that there had been insufficient interaction.

Prompt response to problems is crucial

Students' and tutors' background and end-of-term questionnaires from both conventional and Internet cohorts were examined in order to assess the students' experience of the courses. The 1996 presentation faced a number of 'teething' problems (e.g., faulty communications software, tools under revision, materials not ready), but these subsided after the start of the course, and both students and tutors appear to have been remarkably resilient and tolerant. Tolerance is conditional on the speed of response to technical problems; fast, reliable response reduces students' perception of problems and increases their tolerance for any subsequent difficulties. Students reported that problems solved quickly and sympathetically were quickly forgotten, but problems left unanswered escalated.

Importance of expectations

Questionnaire responses indicated that many of the Internet students would or could not attend face-to-face tutorials, even if available; the electronic presentation attracted a different contingent of students from the conventional course. Those students have different expectations about level and kind of interaction. Starting with appropriate expectations is crucial to a positive experience; tutors and students both emphasized the need to set 'ground rules' for communication. Inexperienced students perceive electronic mail as 'instantaneous' but adjust quickly when told what response time to expect.

Electronic problem sessions

Face-to-face problem and discussion sessions (tutorials) are a focal point in teaching, where concepts become immediate and personal through students' interactions with both their tutors and each other. 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. In order to assess the efficacy of electronic tutorials, we scrutinized all conferences, electronic mail between tutors and students, tutors' logs of tutorials, records of tutor de-briefings, and tutor and student questionnaires [6].

Electronic problem sessions require different models and mechanisms

At the start of the 1996 term, several electronic tutorials were suggested to the tutors, based on an analysis of existing practice. The suggested models tried to accommodate both the constraints and the opportunities inherent in electronic communication in order to provide valuable tutorial functions within the simplest effective technology — and hence emphasised structured, asynchronous tutorials. Those models were woefully inadequate; trying to run electronic problem sessions to mimic face-to-face sessions produced disappointing results. Fortunately, the tutors adapted and invented; identifying new, appropriate structures for electronic sessions proved effective and engaging, e.g.:

- week-long, asynchronous, role-play scenarios using problems built up in stages to effect a cumulative, collaborative solution;
- mixed-mode tutorials incorporating both asynchronous e-mail discussion and synchronous Internet Relay Chat discussion, backed up by logs and question-and-answer digests;

• the 'continuous tutorial', in which problems, issues, and conundrums are set, discussed, and reviewed on a regular basis, with one rolling into the next.

Devices such as fortnightly diagnostic queries (usually single, open-ended questions) and registration for tutorials were found to help draw students into effective interaction.

New patterns of participation; lurkers

In 1996, the number of 'active' participants in electronic tutorials tended to be low, from 1 - 8 students (usually 2 - 5). Nevertheless, many of those tutorials were successful, involving effective, instructive discussion. Tutors who checked with non-participants found that most, if not all, of the remaining students 'lurked' and found doing so beneficial, which students corroborated in their questionnaire responses. Many cited the ability of students to 'lurk' as an advantage of electronic tutorials, even though the lack of direct interaction is frustrating to tutors.

Bringing the social interaction alive

The key seems to lie in bringing the social interaction alive. Some tutors and students achieve this though asynchronous text, whereas others need a 'social starter': a face-to-face tutorial, a synchronous text session, video or audio delivered through the Internet — some way of conveying personalities within the group. All of the groups reporting successful tutorial interaction used plenty of humour, including witty problems and lightly-phrased coaching. Structure also matters: most of the successful tutorials were presented in stages, with clear tasks and milestones, and a clear review of the key points in the material covered.

Assignment marking

Student and tutor questionnaire data, and a substantial corpus of assignments (n = 184: 97 paper; 87 electronic) were scrutinized thoroughly, giving particular attention to the comparison of electronic and paper treatments by 5 instructors with combined groups ([6] gives an interim analysis). A secondary aim was to begin to unpick how individual instructor differences affect adaptation to electronic marking in terms of their strategies, their tool use, and the feedback they provide.

A quantitative coding system was used to capture the quantity and nature of the feedback provided by each instructor. Evidence of re-use of material, use of non-text marks, legibility, and clarity were also noted. Researchers' assessments were corroborated by the monitor's report. Statistical analysis of the quantitative data showed that tutors provide feedback in proportion to the points lost on both paper and electronic assignments. Quantitative and qualitative evidence (including the monitor's report) shows that the nature and quality of feedback are maintained or improved in electronic marking; electronic marking does not appear to impair expression. The greatest gains from electronic handling are in legibility and faster turnaround time. Tutors report that their turnaround for electronic assignments is usually 2-3 days, whereas turnaround for paper assignments is usually 5-7 days. Students report that the total turnaround time for electronic assignments is usually 5-7 days, 2 weeks for paper.

Although quality is maintained, the tutors' experience of marking depends largely on how well their marking strategies and skills match the medium. Tutors' facility in using non-text marks, and the coherence and sophistication of their marking strategies increased during the trial. Speed of marking is largely dependent on typing speed, equipment specification (speed, size of screen), and marking strategy. For example, strategies that involve swapping among different students' assignments carry higher overheads, especially on low-specification machines. On the other hand, electronic marking facilitates re-use of materials, so tutors benefit from strategies that plan for re-use, e.g., amassing a corpus of high-quality re-usable commentary from which selections can be made appropriately for individual work. Electronic marking also facilitates execution of students' code and enables some automated marking. Students, too, can run substitute code or test input provided by tutors, and so electronic handling can lend 'relevance'.

5. Summary: Costs and gains

The value Internet technology brings to distance education lies not in direct translation from other media but in transformation of support mechanisms to exploit its potential range.

Taking care over the integration of the electronic tools into the existing administrative infrastructure paid off. Administration is faster and more efficient with electronic assignments. Turnaround time is reduced; less paper is consumed; access to assignments and records is facilitated; and automatic logging increases accountability. But, on the scale of 150,000 students, there is still real concern about managing demands on communications and about consequences of system breakdowns.

Supported Internet presentation is not a cheap option, but it may be one that can provide greater flexibility and can shift effort from mundane tasks (administrative details) to teaching. We summarize with lists of observed costs and gains.

Costs

- ***More technical support:*** Supported Internet presentation demands suitable technical support from a dedicated resource; in addition to existing computing support services, our trials had a full-time project officer to handle queries. Effective electronic administration requires an unwavering commitment to technical support to maintain key systems continuously.
- ***Tutor expense:*** The highest costs in the initial year were borne by the tutors, who had to master new tools and new skills, evolve a new culture, devise new strategies, prepare

new tutorial materials, and adjust to reduced feedback from students.

- ***Student expense:*** Internet presentation also requires new skills, new strategies, and greater responsibility from students. Some of the presentation costs (e.g., connect time; printing) are off-loaded onto students.
- *equipment upgrades for tutors:* When the quality of equipment the tutors use has such an impact on the time required to do their work, then upgrading equipment must be a priority.
- ***Loss of social interaction for some:*** Except for those who did not seek interaction or for whom conventional face-to-face sessions were never an option, most students were disappointed in their interactions with other students; with limited resources, this is a difficult medium in which to establish a 'community of learning'.
- ***Less satisfactory tutorials:*** Clearly, at this level of technology, electronic tutorials are no substitute for face-to-face interaction, 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.

Gains

- ***More rapid feedback for students:*** Feedback on assignments is a crucial part of teaching; the faster the feedback, the more likely it is to assist learning.
- ***Increased tutor collaboration and communication:*** Re-use and sharing are two crucial means for improving productivity, exploiting expertise, and reducing the load on any one tutor. The increased loads experienced in the early years may well be off-set in subsequent years by the advantages gained in materials collections, re-distributed loads, and so on.
- ***Greater access for students:*** The potential exists for global access.
- ***Increased administrative efficiency:*** The electronic assignment handling, with its automatic checks and record keeping, can substantially reduce the costs of mundane administration, including photocopying costs, while potentially improving the retention and handling of student data.
- ***Reduction in administrative errors:*** The electronic assignment handling system is shown to substantially reduce (if not eliminate) minor administrative errors (currently affecting half a million assignments per year).
- ***Potential for flexibility:*** Students potentially have access to more tutors, more problem sessions, and more different supporting materials as archives and dialogues accumulate on the Web. Tutors can use the breadth of material to address individual needs.

Conclusion

Making the shift to Internet presentation effective requires cultural change by both students and tutors. Students must take responsibility for their own learning and take initiative in bringing problems to the notice of tutors. Tutors must adapt their expectations and practices to accommodate a remote, often invisible student body. Our tutors took up the expanded opportunity for communication as an opportunity for collaboration; Internet presentation may further require culture change from the university, for example by re-organizing the tutor network away from the current regional structure.

But the real key to successful application of technology is good teaching: using technology only when it is a cost-effective servant of pedagogy. Experience has shown that it is easy to propose an electronic solution that is more expensive and time-consuming than the paper-based system it is supposed to improve upon [5]. We must analyse our existing processes deeply and critically in order to provide fully- and appropriately-realized Internet teaching that serves learning at least as well, and at least as economically as conventional methods.

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References

[1] Adamson-Macedo, C., "PCs, the bandwidth revolution and engineering curricula," *IEEE Computing and Control Engineering Journal*, **7** (3), 1996, 129-135.

[2] Carswell, L., "Teaching via the Internet: the impact of the Internet as a communication medium on distance learning introductory Computing students," *ACM SIGCSE Bulletin* (Special Issue: Proceedings of ITiCSE '97 – SIGCSE/SIGCUE Conference on Introducing Technology into Computer Science Education), 1997, 1-5.

[3] Laurillard, D., *Rethinking University Teaching: A Framework for the Effective Use of Educational Technology*, Routledge, 1993.

[4] Petre, M., and Price, B., "Teaching programming though paperless assignments: an empirical evaluation of instructor feedback," *ACM SIGCSE Bulletin* (Special Issue: Proceedings of ITiCSE '97 – SIGCSE/SIGCUE Conference on Introducing Technology into Computer Science Education), 1997, 94-99.

[5] Pilgrim, C.J., and Leung, Y.K., "Appropriate use of the Internet in Computer Science courses," *ACM SIGCSE*

Bulletin, **28** (Special Issue: Proceedings of ITiCSE '96 – SIGCSE/SIGCUE Conference on Introducing Technology into Computer Science Education), 1996, 81-86.

[6] Price, B., and Petre, M., "Large-scale interactive teaching via the Internet: experience with problem sessions and practical work in university courses," *Proceedings of ED-MEDIA/ED-TELECOM '97 Conference* (Calgary, Canada), June 1997.

[7] Reinhardt, A., "New ways to learn," *Byte*, **20** (3), 1995, 50.

[8] Skillicorn, D.B., "Using distributed hypermedia for collaborative learning in universities," *Computer Journal*, **39** (6), 1996, 471-482.

[9] Steeples, C., et al., "Technological support for teaching and learning: computer-mediated communications in higher education (CMC in HE)," *Computers & Education*, **26** (1-3), 1996, 71-80.

[10] 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.