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Teaching Mathematics with Online Tutorials

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Introduction

In 2008 the Open University ran an extensive trial of mathematics and computing teaching using the Elluminate *Live!* synchronous communication software. In this article we report on the success of this trial and on the opinions of both students and staff on their experiences.

The Open University (OU) is the UK's leading distance-learning university with approximately 200,000 students enrolled on (primarily) part-time degrees, and with 15,000 student registrations per annum on mathematics and statistics courses, of which 550 are enrolled on the MSc programme. The OU delivers its mathematics and statistics courses through a blend of high-quality teaching materials (both online and printed) and individual and group support, delivered through a network of 550 dedicated part-time Associate Lecturers (ALs or Tutors).

Historically, the University offered support to its students by telephone, correspondence tuition and face-to-face tutorials. More recently, the OU has successfully added online forums as an effective means to provide tutor and peer support to students. In 2009 the University purchased an extensive licence for Elluminate *Live!*, and now offers support to its students via a blend of all of these media (and a few others, such as podcasts and screencasts).

The Elluminate *Live!* synchronous communication tool includes many features that are particularly useful for online tutorials (e-tutorials). In addition to audio communication, there is a whiteboard with a wide selection of writing and drawing tools (including some very basic mathematical symbols), a text-chat area, a limited selection of emoticons and ticks/crosses for feedback, polling to facilitate whole class interaction, breakout rooms for small group discussions, webtours (taking the class on an internet journey), application and desktop sharing, file exchange, webcams and a recording facility. We refer you to the Elluminate *Live!* website for more information [1].

Some of the tools provided by Elluminate *Live!* are of particular interest for teaching mathematics. A key feature is the ability to upload MS PowerPoint and PDF files (which are converted to the Elluminate whiteboard format) so that pre-prepared mathematical material can be relatively easily displayed on the whiteboard. In addition one can use the snapshot tool in Adobe Reader to copy from PDF files (e.g. those generated by LaTeX) and copy equations directly onto the whiteboard. In addition, Elluminate *Live!* has its own snapshot tool enabling the import of images of mathematics generated, for example, by interactive TeX-based systems such as MathTran [2] and Sitmo [3].

Another important facility is application sharing where applications on the host computer are shared with other participants. This not only provides a mechanism to demonstrate software (and to enable students to interact with it), but also provides an alternative way in which mathematical material can be displayed to students. There is a graphing calculator, but application sharing with more sophisticated graphing tools (e.g. a Computer Algebra System) generally provides a better environment for mathematics tuition. Real-time authoring of mathematics is best achieved by handwriting on the whiteboard using, for example, a tablet PC.

It must be said that not all of Elluminate *Live!*'s features are mathematics-friendly. The in-built mathematical symbols are too basic to be of practical use, the default whiteboard is rather small, and navigation between whiteboards does not allow for easy referencing to previous work. These drawbacks are perhaps inevitable in a system that has not been designed for mathematical use, and it is to be hoped that some of these issues will be resolved in future releases of the software. Nevertheless, Elluminate *Live!* has been used successfully by the Further Mathematics Network [4] to provide tuition to able mathematicians in those schools without the resources to provide Further Mathematics A-level teaching [5]. We can report in this article that the OU has found Elluminate *Live!* to be an effective medium for teaching mathematics at university level.

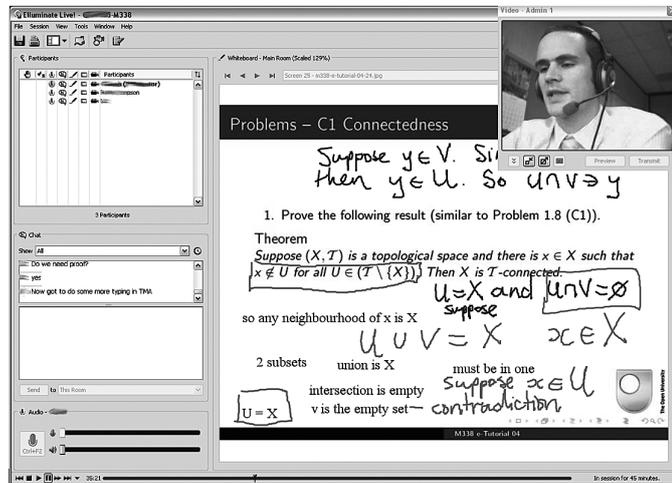


Fig 1 – Author Gareth Williams teaching topology using Elluminate *Live!*

Mathematics Online Elluminate *Live!* trial

In 2008, the Mathematics Online (MOL) Project at the OU conducted an extensive trial of online synchronous tutorials in mathematics, statistics and computer science using the Elluminate *Live!* system. The trial involved 29 ALs (who were given a small remuneration for their participation and feedback), covered a range of Level 1 to Masters courses, in mathematics, computer science, technology and science, and lasted for nine months. Participation in the trial was completely optional for the ALs and for the students in their allocated groups.

The purpose of MOL trial was to answer the following questions:

- (i) How good is Elluminate *Live!* to teach University level mathematics?
- (ii) How can we make best use of the tools?
- (iii) How can the tools be improved?

The trial was evaluated in two stages via surveys of both the tutors and the students. One survey was conducted throughout the trial, with participants completing an online form after each Elluminate *Live!* session. This first survey concentrated on the technical performance and pedagogical effectiveness of the Elluminate *Live!* tools. A second, more extensive survey was conducted at the end of the trial. It looked at the overall experience and at pedagogical, social, privacy, and accessibility issues, and compared e-tutorials with traditional face-to-face (F2F) tutorial sessions.

The first survey produced 485 student responses, of which 49.7% reported that this was their first time as a student in an e-tutorial. Of the 147 staff survey responses, 18.4% said that this was their first time as a tutor, 15.6% their second time, and 16.3% their third time, with the remainder having had more than six sessions previously. It should be noted that many individuals completed the survey multiple times since each participant was asked to complete the survey after each online session.

The second survey, at the end of the trial, was sent out to all students who had been invited to participate in the trial. There were 170 student responses, of which 38.2% had not participated at all, 12.4% had participated once, 14.7% twice, with the remainder having participated in at least three sessions. The second survey to staff had 29 responses, of which all had held at least two sessions as a tutor and 92.1% had held four or more sessions.

Results of the surveys

There is no doubt that students and tutors alike were very positive about the online tutorials, both from a technical and a pedagogical perspective. Fig 2 shows student and staff evaluation of the technical features of Elluminate *Live!* as reported in survey 1 which was conducted after each session throughout the course of the trial.

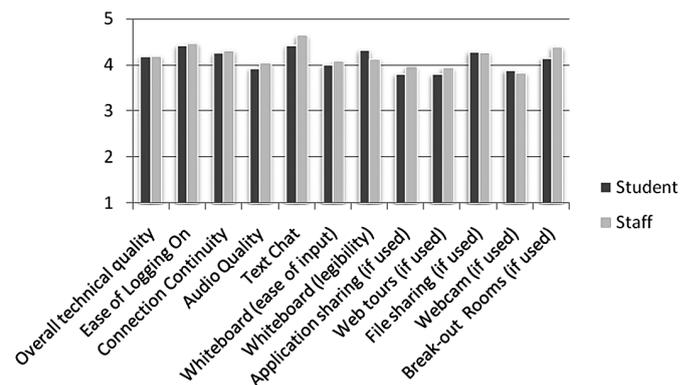


Fig 2 – Student and staff technical evaluations from survey 1: mean scores on a 5-point Likert scale

The 5-point Likert scale has 1 meaning “very poor”, 5 meaning “very good”, and 3 representing “neutral”. As can be seen clearly from Fig 2, there is a good correlation¹ between student and staff experiences of the technology, and, with the exception of audio quality², application sharing, web tours and the webcam, all features got a rating of at least 4 on average. There was an overall technical quality of 4.2 for both staff and students alike.

Fig 3 shows the evaluations of staff and students of the Elluminate *Live!* tools from a learning perspective, throughout the course of the trial. There is a noticeable divergence between the student and staff viewpoint on the usefulness of webcams and of polling, but otherwise there is a good correlation. Again, with the exception of webcams and polling, the responses are at least 4 for both staff and students. With regard to webcams, two things are worth noting. There were relatively few sessions involving webcams and the version of Elluminate *Live!* used in the trial allowed only a single webcam at a time. This was usually the tutor, which perhaps explains the discrepancy between student and staff perspectives on the issue!

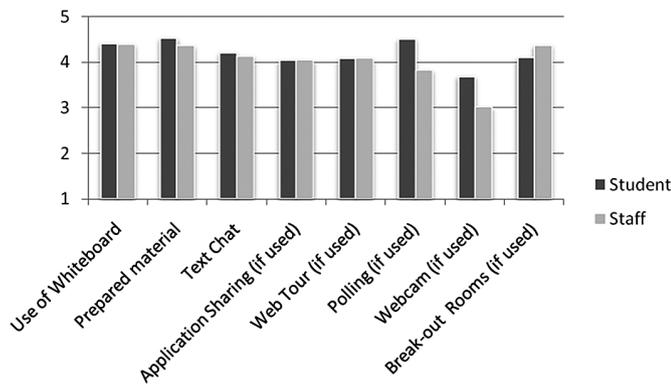


Fig 3 – Evaluation of the Elluminate *Live!* tools from a Learning perspective (5 point Likert scale)

This general picture is supported by the results of the second survey at the end of the trial. Fig 4 shows the results for the second survey.

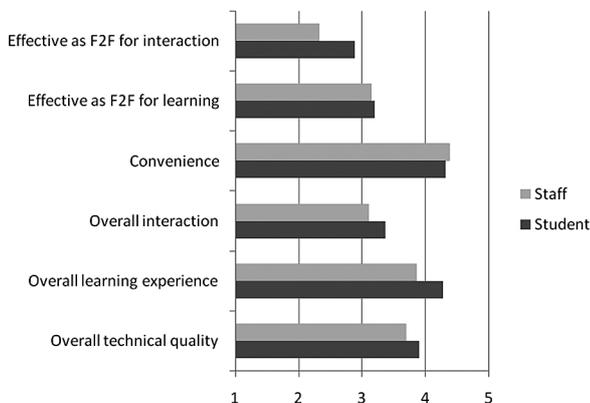


Fig 4 – Overall results for the second survey on a 5-point Likert scale

¹We have not conducted a rigorous statistical analysis of the results.

²The trial used Elluminate *Live!* v. 8.0; the quality of the audio has been improved in later versions of the system.

The student and staff evaluations of the overall technical quality and learning experience are positive, although not so positive as in survey 1. This is to be expected (especially for the staff results) as all participants were surveyed only once in the final survey, whilst the in-trial results are naturally weighted by the number of sessions held, which are likely to be higher for those who had positive experiences.

Fig 4 also shows aggregate results for overall interaction, for convenience, and for comparison with face-to-face (F2F) tutorials. Whilst the view was that online tutorials provide positive interaction experiences, it is perhaps unsurprising that they do not compare well with their F2F counterparts. It is however interesting that both student and staff rate e-tutorials as effective as F2F as a learning experience.

The second survey also surveyed those students who had not participated in the online tutorials, so as to ascertain their reasons for not having done so. Fig 5 shows a chart giving the principal reasons cited in the survey. Whilst not

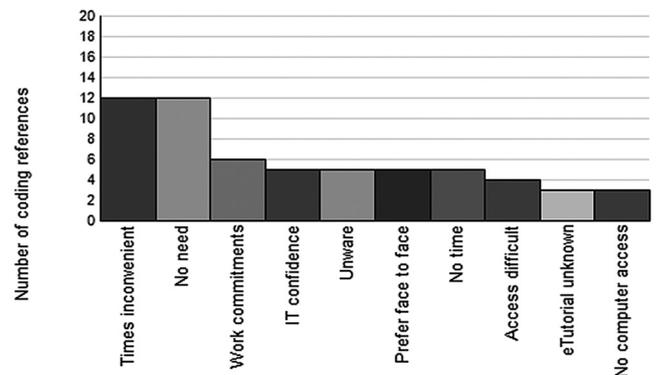
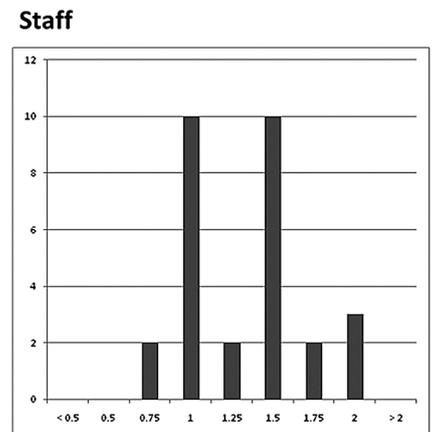
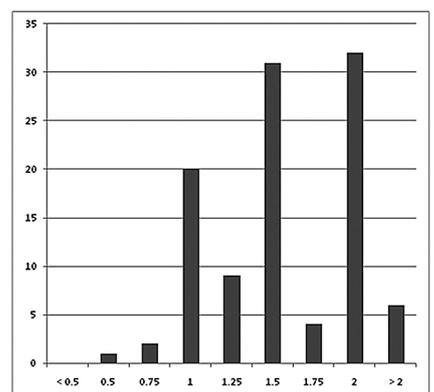


Fig 5 – Reasons given by students for not participating in the e-tutorial trial

Fig 6 – Optimal tutorial time (in hours)



Student



dissimilar to standard reasons given by students in surveys of this kind, lack of IT confidence is perhaps surprising given the scientific bent of this particular student population!

Fig 6 shows the optimal length for online tutorials as estimated by the staff and student groups. There is a clear divergence of opinion, with students favouring a longer tutorial time, whilst tutors (who, of course, do the majority of the speaking in any tutorial) favouring a shorter period. Indeed, it can be tiring for tutors to keep track of the plethora of events happening in the session.

One important question is preparation time. This is particularly important for OU tutors who are paid a fixed salary rather than an hourly rate. Fig 7 shows the tutors' estimation of the preparation time for e-tutorial compared with a F2F tutorial. As might be expected with any new technology, there is a significant initial overhead in preparation, with staff reporting significantly more time for preparation of an e-tutorial than for a face-to-face tutorial. However, staff estimates of preparation time for repeat e-tutorials, whilst greater than for face-to-face tutorials, has a mean of 3.24, much closer to the neutral Likert score of 3.

Initial: compared to F2F

Repeat: compare to F2F



Fig 7 – E-tutorial preparation time compared with face-to-face tutorial, initially and for a repeat tutorial

One criticism of e-tutorials is their lack of accessibility for disabled students, and this is indeed a concern if, as some people envisage, electronic tutorials increasingly take over from F2F. Although our sample size is far too small to make any definite conclusion, we did observe that disabled students' experience of e-tutorials depended very much on the nature of their disability. Those with physical or psychological disability favoured online tutorials, whilst those with aural or visual disability found the Elluminate *Live!* environment difficult. Four quotes from students suffice to illustrate this dichotomy.

- "I suffer from severe chronic clinical depression and have never attended a tutorial because of problems related to confidence, etc. The online tutorial was excellent for me..."
- "Yes I am disabled and without the Elluminate sessions I would not have had any tutorials."
- "I have a hearing impairment and need to lipread - this was not possible ...so I feel disadvantaged."

- "Partially sighted. Had difficulty following what was going on, mainly because there were so many different activities simultaneously, and screen reader can only focus on one at a time."

One other accessibility issue is internet bandwidth. Some students had dial-up connections whilst most had broadband. One feature of Elluminate *Live!* is the intelligent way it handles different connection speeds and makes good use of the available bandwidth.

Staff: likely to give eTutorial in future, mean = 4.55, s.d. = 0.93

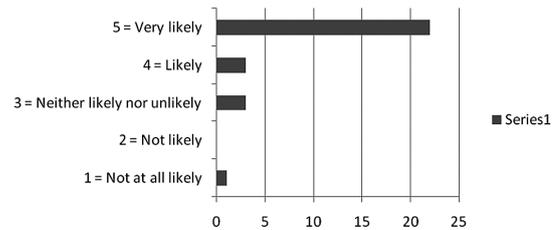


Fig 8 – Intended staff future use of Elluminate *Live!* for e-tutorials

What of the future? We asked the tutors whether they were likely to give an e-tutorial in the future. Fig 8 gives their response, which indicates that the tutors have formed a very favourable impression of the medium. The student viewpoint is given in Fig 9.

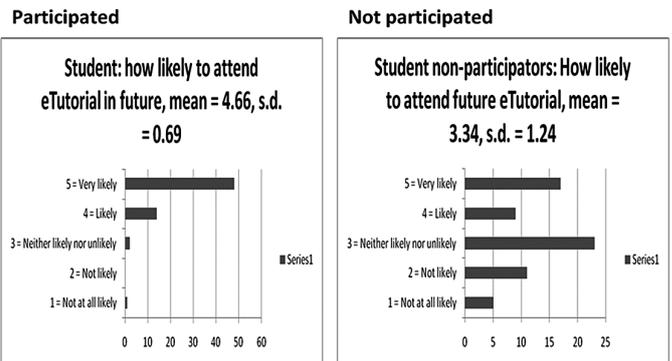


Fig 9 – Student intention for future participation in an e-tutorial: participators (left) and non-participators (right).

It is clear from this figure that those respondents who participated in the e-tutorial trial have indicated a very strong likelihood that they will do so again in the future. For those students who did not participate in the trial, there is a much more mixed set of intentions, but still a mean of 3.34 indicating an overall intention of attending an e-tutorial in the future.

Issues for mathematicians conducting online tutorials

During the trial, students and staff were asked for their comments on their experiences. Fig 10 and Fig 11 (overleaf) indicate the important issues identified by the students during the first survey.

Students liked the interaction, the convenience, the support they received from their tutor, and the helpfulness of the

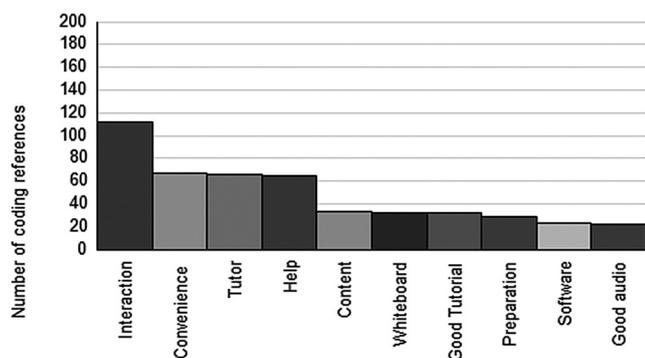


Fig 10 – Positive comments classified by topic expressed by students during the trial.

sessions, as well as the content and preparation of the tutorials by the tutor. The whiteboard was commented favourably on, as was the audio and the features of the Elluminate *Live!* software itself.

However, students' audio experiences varied greatly and, in fact, from Fig 11, it is clear that sound problems (including echo) formed the largest number of issues raised by students during the trial. It is worth recording that the second most common cause of complaint was 'nothing', again illustrating the generally positive student experience of the software. Other issues raised were connection problems and the difficulty of logging on, application sharing and a lack of interaction (despite many students' positive experience of interaction during the e-tutorial).

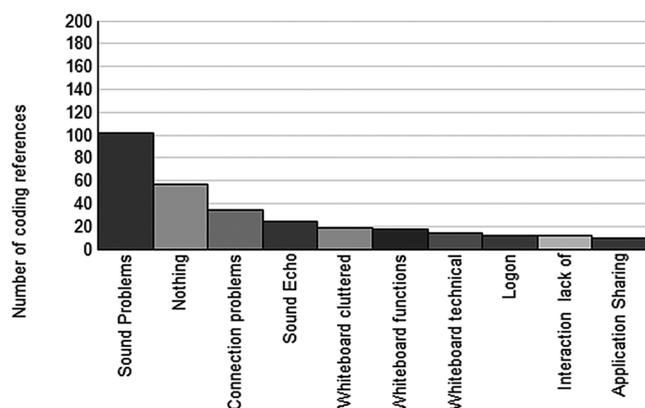


Fig 11 – Negative comments classified by topic expressed by students during the trial

Another major issue was the whiteboard: technical problems, functionality and the tendency of the whiteboard to become cluttered. Since the whiteboard is of major importance for mathematics and statistics teaching, we deal with it in detail.

Mathematics and statistics teaching requires extensive board use and one complaint of students and tutors alike was the lack of space on the whiteboard. Although Elluminate *Live!* has an unlimited number of whiteboards which can be used, navigation between the boards is limited and, in particular, it is not possible to view more than one board at once, even as a thumbnail, so that it is not easy to refer to previous work as one might do, for example, during a face-to-face class.

One way round this limitation that has been used by several tutors is to share an application which gives a scrolling whiteboard. However, application sharing is one feature that is very much bandwidth dependent and can be a frustrating slow and disjointed experience for participants on low-speed connections. It is also possible to increase the Elluminate whiteboard size, but this requires action by both staff and students, which can be problematic.

Elluminate *Live!* has few mathematically oriented tools and the mathematical symbols are insufficient for any serious mathematical work. There is a graphing calculator which can be useful for simple graphs, but for anything sophisticated one would use the application sharing functionality together with a graph drawing program or computer-algebra system.

For writing mathematical notation on the whiteboard there are three principal methods, all of which are useful in different circumstances. It is perhaps worth noting that the first two methods require the use of a mathematical typesetting package external to Elluminate *Live!* It is not clear that such a skill may be reasonably expected of a student who is studying, say, an introductory level course.

First, one can prepare mathematical material using, for example, the Beamer class in LaTeX [6], and convert the resulting PDF slide show to the whiteboard. MS PowerPoint may also be used. This is often the most convenient manner and gives structure to the session. However, it is not a convenient method for producing mathematical material on the fly.

Second, one can use a mathematical typesetting system (e.g. LaTeX or MS Word) to produce mathematical notation in real time, which is then pasted onto the whiteboard. This can be an effective way to write mathematical notation onto the whiteboard, provided one can typeset mathematics quickly and accurately.

However, the third and most widely used method is to write on the whiteboard using a digital pen, most conveniently using a tablet PC. Although some of the tutors successfully used other modes of input (such as USB graphics tablets), the use of a tablet PC seems to be the most successful, both from a quality-of-output viewpoint and from a convenience-for-the-tutor viewpoint.

One of the most potentially useful features of Elluminate *Live!* is application sharing, certainly for computer scientists, but also for mathematicians. During the trial, one of the tutors successfully used the application-sharing feature to teach Mathcad to students [7].

Conclusions

Conducting online tutorials in the mathematical sciences using a synchronous communication software tool such as Elluminate *Live!* can be an effective means of distance learning in mathematics and statistics at university level.

