

Computer-based teaching is as good as face to face lecture-based teaching of evidence based medicine: a randomized controlled trial

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Abstract

Background: Assessing in undergraduate medical education the educational effectiveness of a short computer-based session, integrating a lecturer's video with a standardized structure, for evidence based medicine (EBM) teaching, compared to a lecture-based teaching session of similar structure and duration.

Method: A concealed, randomized controlled trial of computer based session versus lecture of equal duration (40 minutes) and identical content in EBM and systematic reviews. The study was based at the Medical School, University of Birmingham, UK involving one hundred and seventynine year one medical students.

The main outcome measures were change from pre to post-intervention score measured using a validated questionnaire assessing knowledge (primary outcome) and attitudes (secondary outcome).

Results: Participants' improvement in knowledge in the computer based group was equivalent to the lecture based group (gain in score: 0.8 [S.D = 3.2] versus 1.3 [S.D = 2.4]; $p=0.24$). Attitudinal gains were similar in both groups.

Conclusion: Computer based teaching and typical lecture sessions have similar educational gains.

Introduction

Computer based teaching sessions have advantages over lectures: they are more flexible to fit into their work and learning programme; there is the ability to pause or revisit areas of the session; they have more learner led interaction; hyperlinks and additional materials can be provided instantly for the learner; they address the issue of standardizing the quality of teaching materials across a region; and they deal with the cost and logistical difficulties of specialist lecturers teaching large numbers of students in different locations (Greenhalgh 2001). There have been trials comparing different e-learning educational interventions and other non e-learning formats. (Chan et al. 1999; Hutchinson 1999; Gerbert et al. 2002; Curran & Fleet 2005) There are existing studies of knowledge and attitudinal gain by e-learning at undergraduate level (Williams et al. 2001; Leung et al. 2003; Lau & Bates 2004). These have mainly been uncontrolled, small observational studies. It is perhaps a forgone conclusion that in the future undergraduates will do the majority of learning using computers, although currently we do not have much high quality evidence in the form of randomized controlled trials to support this conclusion. It is therefore important to build this evidence base for teaching and learning in undergraduate medical education.

Education of medical students can be enhanced through the use of computer assisted learning. Undergraduate learning is generally driven by external factors such as curriculum and

Practice points

- Computer based sessions fit around students workloads, and can be done at an individual's own time and place, standardizing the quality of teaching.
- There have been a number of studies looking at computer based teaching of undergraduates, but these have mainly been uncontrolled observational studies.

What this study adds.

- Computer based teaching of EBM and systematic reviews is as good as lecture based teaching for improving knowledge.
- Computer based teaching produces the same attitudinal gains as lecture based teaching.
- This high quality randomized controlled trial adds to available data.

examinations. By using the advantages of computer assisted learning it could be possible to draw students away from such superficial learning styles and create interactive packages which would promote deeper learning (Reid et al. 2005).

Randomized controlled trials can provide robust evidence of educational effectiveness (Smits et al. 2003). Randomized trials, in education could suffer due to difficulty with standardising the educational intervention(s), contamination

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between the two arms of a study, inability to blind the study participants and the teachers from the educational intervention(s) leading to selective co intervention, and finally difficulty with measuring outcomes due to the lack of valid and reliable assessment tools. Some of these factors make randomized trials unfeasible in educational settings, thus necessitating other designs such as non-randomized controlled and before and after studies. Despite such difficulties randomized trials have been conducted into educational interventions with some success (Coomarasamy & Khan 2004).

We carried out a randomized controlled trial comparing two methods of teaching, designed in such a way so as to avoid the problems outlined above. EBM was chosen as the teaching topic as this important area in clinical medicine (Sackett 1997) is considered mandatory (The General Medical Council 2005) and it can be taught using computer based sessions or lectures. We hypothesized that both teaching strategies will be equally effective in increasing students' learning.

Methods

We conducted an individual randomized trial to assess the effect of teaching using self administered questionnaires before-and-after the intervention. The trial was carried out in May 2006. The study was approved by the University of Birmingham Medical School. The trial compared a short computer based session with an equivalent lecture, of similar content, structure and duration, for their educational effectiveness.

Students were randomized to either computer based session or lecture using sealed envelopes prepared by the Birmingham clinical trials unit. The randomization sequence was generated by computer and the envelopes were coded by a third party to ensure concealment of randomization. The format of the session consisted of: baseline questionnaire; randomization of students; simultaneous administration of educational interventions in separate areas to prevent contamination followed by post intervention questionnaire. The time allocated for teaching was forty minutes and ten minutes for each questionnaire.

The interventions consisted of (A) Computer based session and (B) Lecture based session. The content covered EBM teaching on question framing, literature searching, critical appraisal of systematic reviews and meta-analysis, and application of findings of systematic reviews, analogous to the problem-based approach in teaching and learning. The lecture was scripted and then recorded for the computer based version. The recording was then merged with power-point slides and links using Microsoft™ producer, this can be seen below in screen shot 1. Computer-based session delivered non-linear teaching allowing students to navigate between subsections to aid their learning. This was delivered to participants in the medical school computer cluster using individual personal computers and headphones. The computer group was not exposed to the lecture before hand. The lecture based session consisted of exactly the same material, delivered in a typical linear fashion using a session plan by the same tutor, with opportunities for questioning by students at the end. Every possible effort was made to ensure the lesson plans and educational pedagogies were equivalent

The screenshot shows a web browser window with the following content:

How does an EBM approach work?

- STEP I: Identify a clinical information need.**
- STEP II: Formulate a structured clinical query**
 - Allows you to clarify the question in your mind
 - Helps you do literature search
- STEP III: Search and retrieve literature**
 - Choose the highest quality evidence
- STEP IV: Critically appraise the literature**
 - Evaluate quality of the literature
 - Evaluate the importance of the findings
 - Assess the relevance of the findings to your population
- STEP V: Apply if appropriate.**
 - Clinical benefit to your patient
 - Side-effects
 - Patient's views and perception
 - Costs

The left sidebar of the browser shows a table of contents with the following items:

- Evidence Based Medicine (EBM) ...
- Introduction
- Approach
- Steps?
- Step 1 : Identify a clinical Inform...
- How does an EBM approach work?
- Step 2: Formulate a structured ...
- Step 2: Formulate a structured ...
- How does an EBM approach w...**
- Step III Search and retrieve Lite...
- Hierarchic approach for searchin...
- Search results
- Guideline:Secondary prevention ...
- You find an SR: Identified throu...
- Okay so...
- How does an EBM approach work?
- Meta analysis:
- Quality assessment of a system...
- Forest plot
- So off to the For(rest) (plots).....
- Outcome: MI/stroke/vascular de...
- Outcome: Non-fatal myocardial l...

Screenshot 1. From the evidence based medicine trail.

in the two groups; the only differences related to the methods of delivery.

The intervention was CD-ROM based, but was developed in a format that could be directly uploaded onto the internet. The teaching package was developed in conjunction with the University of Birmingham's computer science department. The cost in producing the package was minimal, well within normal departmental budgets for teaching undergraduates. Microsoft™ producer was used as Microsoft™ is currently the platform of most university and NHS operating systems and is freely available.

We developed a questionnaire for pre and post intervention measurements in knowledge and attitudes using previously validated assessment tools for evaluating EBM teaching (Awonuga et al. 2000; Fritsche et al. 2002; Ramos et al. 2003). From previous studies the questions were shown to have face and concurrent validity. Items included for knowledge assessment (primary outcome) were carefully chosen and adapted so as to achieve content validity. These were five knowledge questions (two structured questions and three multiple choice questions) with a pre-determined validated marking scheme, with a maximum score of 16. There were six attitudinal questions, previously validated for content validity, on a five point Likert scale (Taylor et al. 2001). The questionnaires were marked by an examiner blind to group allocation.

Our hypothesis was that the ability of both interventions to change students' scores would be similar. Thus we defined the primary outcome to be the change (improvement) between baseline and post intervention knowledge assessments. We predefined the range of equivalence between both arms of the trial as any difference between both groups in this variable lying within 10% of the maximum score (± 1.6 points). Assuming that the standard deviation (S.D.) of the change will be 2 points, we needed a minimum of 25 subjects in each group to have 80% power with a 5% type I error rate to

exclude a difference between both groups greater than the equivalence threshold. We used ANCOVA to compare score changes in the two study groups, with teaching interventions as the main factor and baseline score as a covariate (Vickers and Altman 2001). To estimate the difference between intervention groups, difference between least-squares means and corresponding 95% CI were calculated based on the ANCOVA model. For ordinal data (Likert scales), non parametric statistics were used. To compare the proportion of participants with attitudinal gain we used Fisher exact tests. All statistical tests were two-sided with a significance level of $p < 0.05$. Analyses were done using SPSS version 12.0 (SPSS Inc.)

Results

The flow of participants throughout the trial is shown in Figure 1. The baseline characteristics of the two groups are shown below in Table 1. Assessment done immediately after the intervention revealed that both groups significantly improved their knowledge scores as shown in Figure 2. The changes in score in the computer based teaching group and the lecture based teaching group were 0.8 [S.D 3.2] and 1.3 [S.D 2.4] respectively. The difference between the groups was -0.5 (95% CI -1.3 to 0.3 ; $p = 0.24$) (ANCOVA model difference -0.8 ; 95% CI -1.4 to -0.1 ; $p = 0.02$), which is well within the pre-specified equivalence range. Comparison of attitudinal gains between the two groups showed a similar change between baseline and post-intervention (Table 2).

Discussion

This trial showed that when teaching EBM and systematic reviews to undergraduate medical students, knowledge and

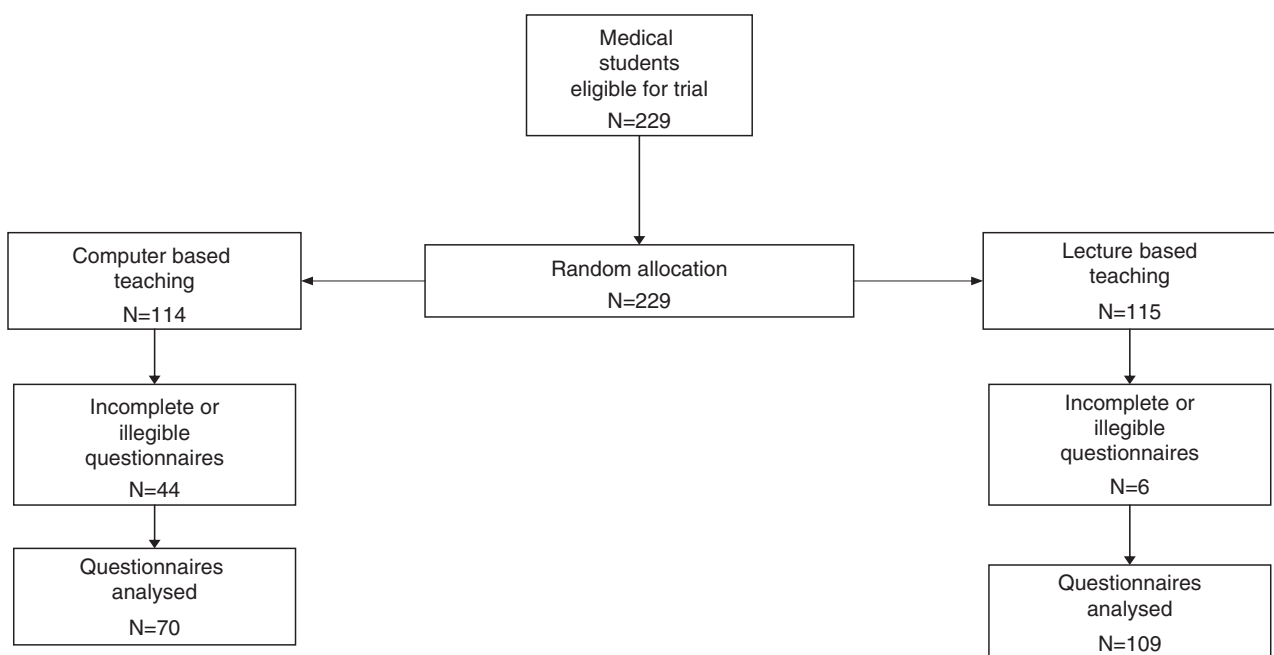
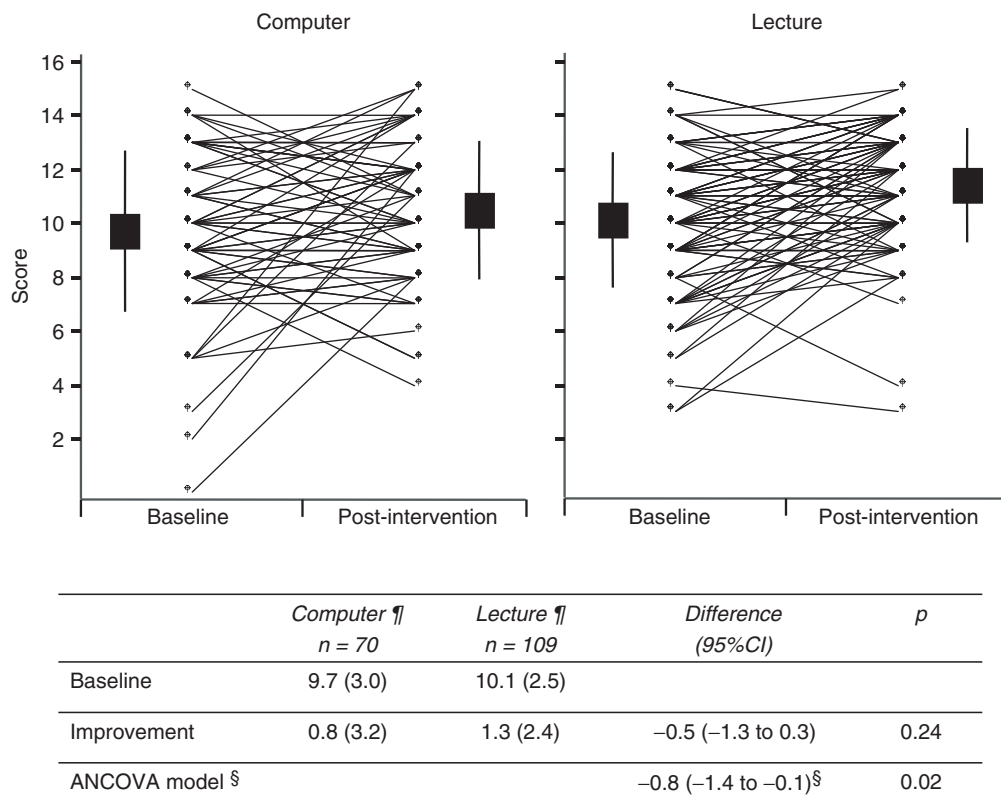


Figure 1. Flow chart of study participants in the evidence based medicine teaching trial.

Table 1. Baseline characteristics of participants in evidence based medicine teaching trial.

	Computer <i>N</i> = 70 <i>n</i> (%)	Lecture <i>N</i> = 109 <i>n</i> (%)
Access to a staffed medical/health care library	60 (85.7)	103 (94.5)
Access to literature via the internet	61 (87.1)	104 (95.4)
Searched the literature for evidence	57 (81.4)	99 (90.8)
Education or training in research methods	53 (75.7)	94 (86.2)
Education or training in epidemiology	52 (74.3)	94 (86.2)
Education or training in statistics	30 (42.9)	47 (43.1)
Personally been involved in conducting research	16 (22.9)	19 (17.4)



\bar{x} Data are means (SD)

\S Difference in least squares means (ANCOVA model adjusted for baseline score). There were no differences between interventions at baseline.

Figure 2. Comparison of knowledge scores achieved through computer-based session versus lecture. Dots show data for individual participants. Boxes with vertical whiskers show means and SD.

attitudinal gains are similar between computer based session and lecture.

Our study represents a good quality protocol for a randomized controlled trial. We were able to comply with CONSORT (Moher et al. 2001) guidelines for reporting. There was concealment of randomization, however, the groups' baseline characteristics (Table 1) reflected a small difference, which is a random phenomenon as groups were generated by using a chance procedure. All interventions were delivered by the same tutor, there was no contamination of interventions, the assessment was validated and blinded, and the power was sufficient to demonstrate equivalence. However we had a substantial drop-out post randomization from the computer based group. One may conclude that it is more difficult to get students to attend and complete a computer based session, but there could be many reasons for this

finding. The most likely reason is that in the absence of direct supervision by a teacher, the computer based group student's did not participate in the study any further after pre-intervention questionnaire. There is no equivalent of the physical presence of a lecturer in the computer-based teaching, so it is possible that drop-outs cannot be captured symmetrically in the two groups. Students' participation in the study was totally voluntary and the element of teaching being covered was elective. We did our best to chase non responders with mail shots, but this approach was unsuccessful. The observation of a large drop-out rate may be indicative of student preference for tutor delivered lecture over computer based teaching (Steele et al. 2002, Hudson 2004).

Our finding that gains were similar between computer based session and lecture could be criticized for the small amount of mean improvement. The improvements were

Table 2. Comparison of attitudinal gains achieved through computer-based session versus lecture.

		Group		<i>p</i>
		Computer <i>n</i> (%)	Lecture <i>n</i> (%)	
A	Gain	19 (27.1)	24 (22.2)	0.704
	No change	45 (64.3)	72 (66.7)	
	Loss	6 (8.6)	12 (11.1)	
B	Gain	25 (35.7)	27 (25.0)	0.015
	No change	37 (52.9)	49 (45.4)	
	Loss	8 (11.4)	32 (29.6)	
C	Gain	35 (50.0)	50 (46.3)	0.889
	No change	26 (37.1)	44 (40.7)	
	Loss	9 (12.9)	14 (13.0)	
D	Gain	24 (34.3)	29 (26.9)	0.136
	No change	35 (50.0)	48 (44.4)	
	Loss	11 (15.7)	31 (28.7)	
E	Gain	33 (47.1)	44 (40.7)	0.274
	No change	27 (38.6)	54 (50.0)	
	Loss	10 (14.3)	10 (9.3)	
F	Gain	16 (22.9)	15 (13.9)	0.078
	No change	41 (58.6)	58 (53.7)	
	Loss	13 (18.6)	35 (32.4)	

The questions used to assess attitudes were as follows: A. EBM is a passing fashion; B. Systematic reviews play a key role in informing evidence-based decision-making; C. Clinical judgement is more important than EBM; D. Systematic reviews are key to informing EBM; E. Evidence-based decision-making is health care by numbers; F. Study design is important in article selection. Responses were measured on a five points Likert scale. Attitudinal change was defined as the change between baseline and post intervention assessments.

statistically significant and we found that a majority (*n/t* % in computer group and *n/t* % in lecture group) of students had improved and this is not captured well by the mean. Our results have implications for the way in which undergraduate trainees can be taught. The trial's generalisability may be limited in that the educational intervention itself was brief and only looked at a specific teaching area of EBM and systematic reviews. In this study, only one teacher was involved and it is possible that outcomes would differ between teachers. Similarly, home based web-delivered learning may achieve a different learning experience to delivery in a computer cluster. Our study does however form an important addition to what is known. It allows for the development, adaptation and evaluation of new e-learning techniques for wider application in undergraduate education.

E-learning has the potential to meet medical training needs and other professions have already started to embrace it in undergraduate and continuing professional education (Stephens & Grigg 1994; Grigg & Stephens 1998; Ellis et al. 2003). Our trial suggests that computer based teaching is a viable alternative to lectures, at least for the teaching of EBM. Computer-based teaching might be confused with a video recorded lecture. Our e-learning package was more than just a recorded lecture as shown in Screenshot 1. It did not deliver linear teaching and took advantage of the navigation features of the computer medium allowing for a tailored learning experience. Efforts would have to be made to engage students with this medium. For those who did not attend sessions or dropped-out it would be available at other times, whereas lectures could not be readily repeated for non-attenders. This

would be a massive advantage in practice. Computer based sessions also allow standardization of teaching between institutions and addresses the difficulty of teaching a large number of students dispersed over different sites. Computer based learning can be made interactive to encourage better deeper learning (Harden et al. 1984). The addition of links to material on the web or contained in other files can enhance the learning experience. With such enhancements, computer based teaching may perform even better than lectures, a hypothesis that will no doubt be subject of future research. As undergraduates qualify and move into continuing medical education computer based teaching is a natural progression to meet demands for knowledge.

Our recommendation is that computer based teaching is an alternative to lecture based teaching in EBM for undergraduates. For cost and logistic reasons, computer delivered lecture method may provide a way to achieve standardization of content delivery for the widest possible audience. We need to conduct further research to explore the wider potential of e-learning in medical education to improve student engagement with this educational medium.

Notes on contributors

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