Optimal sequencing of bedside teaching and computer-based learning: a randomised trial

Peter Hull,[1] Adnan Chaudry,[1] Anna Prasthofer[2] & Giles Pattison[3]

OBJECTIVES We aimed to establish the most effective order in which to deliver teaching to medical students when using both bedside teaching (BT) and computer-based learning (CBL) and to ascertain the students' preferred method and order of delivery.

METHODS A sample of 28 medical students were randomly divided into two equal groups during their orthopaedic knee examination teaching session. Group 1 received standard BT and group 2 undertook a CBL package. Each group then undertook an objective structured clinical examination (OSCE). The groups then received the other method of teaching followed by another OSCE. A questionnaire was administered to all students to assess their views on, and preferences for, the various teaching methods.

RESULTS Mean scores on the first OSCE were 12.19 for group 1 (BT then CBL) and 11.96 for group 2 (CBL then BT) ($P = 0.692$). Mean scores on the second OSCE were 11.81 for group 1 compared with 12.79 for group 2 ($P = 0.038$). Statistical analysis showed a significantly better score improvement for group 2 (CBL then BT) over group 1 (BT then CBL). Of the 26 students who returned questionnaires, 24 (92%) expressed their preference for traditional BT over CBL only, and 23 (88%) were in favour of undertaking CBL prior to traditional BT.

CONCLUSIONS The CBL package is a useful tool and is most effective if used before BT. Students prefer BT alone over CBL alone, but, if offered both, prefer to undertake CBL first.

KEYWORDS randomised controlled trial [publication type]; computer-assisted instruction/*methods; education, medical, undergraduate/*methods; *point of care systems; physical examination; personal satisfaction; students, medical/*psychology.

Medical Education 2009: ***43****: 108–112*
doi:10.1111/j.1365-2923.2008.03261.x

[1]Department of Trauma and Orthopaedics, Worcestershire Royal Infirmary, Worcester, UK
[2]Department of Trauma and Orthopaedics, Heart of England Foundation Trust, Birmingham, UK
[3]Department of Trauma and Orthopaedics, University Hospital Coventry and Warwickshire, Coventry, UK

Correspondence: Peter Hull, c/o Mr Pattison sec, UHCW, Clifford Bridge Road, Coventry, CV2 2DX. Tel: 00 44 7779 579718; E-mail: peterhull@doctors.org.uk

INTRODUCTION

Computer-based learning (CBL), computer-based video instruction and distance learning have been promoted increasingly as new and effective techniques of teaching in various educational settings, including medical schools.[1] In many medical schools knowledge transfer is carried out mainly through traditional methods, namely, lectures along with tutorials. Clinical skills are traditionally taught at the bedside in a non-standardised manner.

In this study we compared a modern method of teaching using CBL with traditional bedside teaching (BT) and studied how the order of teaching delivery affected students' performance.

The aims were to determine:

1 the effect of interactive DVD-based instruction combined with traditional BT and the best order in which to deliver these two teaching methods;
2 students' preferred method and order of delivery of the teaching, and
3 the efficiency of knowledge transfer through CBL compared with standard BT.

We were particularly interested in establishing the best order in which to deliver teaching to the students, and hence undertook a 'within-medium study' as advocated by Cook.[2] Cook and others have been critical of studies that simply compared computer-based teaching with non-computer-based teaching as, they argue, 'it is logically impossible, because there is no true comparison group'.[3,4] In this study we were able to compare CBL alone with standard BT alone, but the most powerful analysis, both statistically and practically, concerns the optimal sequencing of the two teaching methods when they are delivered one after another.

The constructivist model of learning is founded on the notion that all new knowledge is built upon knowledge that we already maintain. Students entering their Trauma and Orthopaedic block have had little exposure to specific musculoskeletal examination training and their first exposure to this learning represents a key time for their conceptualising of this information. The way in which these students are exposed to this material is key to their establishment of a sound basis on which to develop their clinical skills. In practical terms, if CBL prior to contact with teaching staff could be shown to be useful, then this might indicate a way of integrating CBL painlessly into clinical teaching without having to increase staffing resources, but, we hope, improving final student performance. Bransford and Johnson have shown that a certain level of prior knowledge and understanding is required in order to meaningfully process new information.[5] Guided prior reading and the CBL package may provide this basis. Alternatively, students might well have conceptualised a clinical examination paradigm from their previous studies, which, although not based specifically on musculoskeletal examination, might provide an appropriate framework for their learning. The CBL might not add anything and the order of delivery might have no effect on their learning. This formed the null hypothesis for our study.

METHODS

Study material

An interactive computer-based package was produced by PH (the primary author). It covered in full the students' knee examination curriculum. The package consisted of a PowerPoint presentation, with written and pictorial slides, as well as video clips of PH performing the examination techniques with commentary. The students were able to navigate between slides at their own pace, repeating segments as they wished.

Study design

The study group included 28 medical students from Warwick Medical School. These students were all graduates and had completed, at the least, a first degree in biomedical sciences. All students rotate through an 8-week block in Trauma and Orthopaedics and receive specific training on musculoskeletal clinical examination techniques. Students were randomised into two equal groups by an independent operator using a computerised randomisation package. All students were asked to prepare for the session by reading the relevant chapters in the set textbook on clinical examination, which was issued to them at the start of the block.

Group 1 (BT then CBL) received sessions in this order:

1 BT;
2 objective structured clinical examination (OSCE) 1;
3 CBL, and
4 OSCE 2.

Group 2 (CBL then BT) received sessions in this order:

1 CBL;
2 OSCE 1;
3 BT, and
4 OSCE 2.

Each session lasted for 1 hour. All students undertook the normal 1-hour BT session. The further 3 hours of OSCEs and CBL were voluntary. The students were informed that their results would be used in this trial.

Bedside teaching was delivered by a senior specialist registrar (SpR) in Trauma and Orthopaedics. This SpR taught both groups. Prior to the session he was briefed in detail on the topics that needed to be covered and the teaching was standardised and tailored to reflect the knee examination curriculum.

The CBL session took place in a computer room. No clinician was present, but students were encouraged to practise examination technique on their colleagues during this time. The OSCEs were all standardised (Fig. S1; available online as supporting information) and had been validated previously by the medical school. This OSCE is used in the end-of-block assessment. The maximum mark was 14, with each mark representing a key point in the examination process. Examiners were blinded to the methods of teaching the students had received and the order in which they had received them.

Once the teaching sessions and OSCEs were completed, each student was given a questionnaire to assess his or her satisfaction with the teaching sessions and to determine preferred methods and order of teaching (Fig. S2). The repeated measures analysis of variance (ANOVA) was used to test for differences in OSCE scores between treatment groups at the two assessment occasions. Model diagnostics indicated that assumptions of normality and heterogeneity of variance were valid for these data. A *P*-value of < 0.05 was taken as statistically significant.

RESULTS

The OSCE scores for one of the students in group 1 were markedly different from all other scores on both occasions (5 and 7, respectively, out of 14). These scores were considered to be extreme outliers so were removed from the analysis. At the first OSCE, group 1 achieved a mean score of 12.2 (range 10.5–14) and group 2 scored a mean of 12.0 (range 9–14). At the second OSCE, group 1 achieved a mean score of 11.8 (range 10–14) and group 2 scored a mean of 12.8 (range 11–14) (Table 1). A repeated measures ANOVA indicated there was no significant difference in OSCE results at occasion 1 ($P = 0.692$), showing that, taken individually, there was no difference in OSCE scores achieved after traditional BT or CBL. However, the ANOVA showed a significant interaction between the group and assessment occasion factors, indicating a significantly better score improvement for group 2 than for group 1 ($P = 0.038$) after the second assessment. This offers evidence that if students are taught using both methods, they do significantly better if they have CBL followed by BT, than if they have BT followed by CBL.

With regard to each group's second OSCE result, the decline observed in group 1 using a *t*-test was not statistically significant ($P > 0.3$). However, the improvement in group 2 approached significance ($P < 0.06$).

Table 1 Means and standard deviations of OSCE scores at occasions 1 and 2

	OSCE scores Mean (standard deviation)	
	Group 1 BT then CBL (*n* = 13)	**Group 2 CBL then BT (*n* = 14)**
OSCE 1	12.19 (1.13)	11.96 (1.46)
OSCE 2	11.81 (1.25)	12.79 (0.96)
Improvement	– 0.38	0.82

OSCE = objective structured clinical examination; BT = bedside teaching; CBL = computer-based learning

Table 2 Questionnaire results

Preferred method of learning			
BT only	CBL only	CBL before BT	BT before CBL
24 (92%)	2 (8%)	23 (88%)	3 (12%)

BT = bedside teaching; CBL = computer-based learning

A questionnaire was administered to all students to assess their satisfaction with the teaching session. Of the 28 given out, 26 (93%) questionnaires were returned. A total of 24 (92%) students preferred BT over interactive CBL. In response to the question on preferred sequence of teaching techniques, 23 (88%) students preferred to undertake the CBL package prior to the traditional BT session, and 24 of 26 (92%) considered it would not be acceptable to have clinical examination teaching delivered by CBL alone (Table 2).

DISCUSSION

The impact of new technologies on the processes and outcomes of teaching and learning in universities is substantial and is growing rapidly, with the result that developments are occurring faster than they can be properly evaluated.[6] As Percival *et al.* state, 'Much of the evaluation that is being conducted is from the teacher's perspective, focusing on learning gains by students on tests produced by teachers, and improvements in the productivity of teaching and learning.'[6] Research or evaluation purely on the students' experiences of using these new technologies is limited, and thus we have little information from the students' perspective.

Other studies have found that computer-based teaching can be used to teach practical skills. Xeroulis *et al.* found that computer-based video instruction (CBVI) can be as effective as summary expert feedback in delivering instruction on basic technical skills (suture knot tying) to medical students.[1] They concluded that, when it is thoughtfully incorporated into the curriculum, CBVI can make efficient use of faculty time and serve as a useful adjunct for basic skills training.[1] Ridgway *et al.* found widespread approval of web-based learning as an adjunct to conventional teaching in the surgical curriculum.[7] They also found that the addition of aural files to the novel web-based lecture series is face valid and results in significant improvements in examination performance.[7]

There has, however, been much criticism of what Friedman has characterised as 'media-comparative' research.[3] In 1994 he pointed out that comparison between the use of CBL and traditional teaching is 'logically impossible' and can be meaningful only 'if the computer offers educational methods that cannot be delivered by any other medium'. A decade later Cook updated the agenda for research in CBL, arguing for 'within medium' studies.[2] These are studies that compare different ways of using CBL in Cook's framework, whereas our study seeks to address changing the instructional method rather than the configuration or presentation of the CBL package. We are not aware of any published studies that have performed a within-medium study like this and have also evaluated students' preferred order of teaching delivery.

Our results showed there was an improvement in mean OSCE results for group 2 students, who used the CBL package before receiving a face-to-face teaching session. This confirms our theory that, for this group of students, at this time in their learning trajectory, they benefit from gaining core knowledge from the CBL package and can use this knowledge to construct a framework, after which they can make the most of their clinical learning opportunities. This conclusion was supported by comments on the students' feedback forms such as: '…the DVD gave me the basic knowledge to then interact and question during the teaching session – rather than [to] simply sit back and be taught.'

Group 1 students, who were given a traditional face-to-face teaching session first, failed to improve on their score in the second OSCE after using the CBL package. The students' feedback forms indicated that this group found the interactive DVD session unproductive as they had already spent time with the tutor face-to-face and all their questions had been answered during the first teaching session. In this group, further knowledge transfer was ineffective, as was established by the mean results of the second OSCE (no improvement).

Based on OSCE results, we can conclude that CBL is as effective as BT because there was no statistically significant difference between the groups in results on the first OSCE ($P = 0.69$). However, using CBL alone would not find favour with students: 92% of them rejected it as an appropriate method of teaching.

This finding has been described before. Steele *et al.* showed that students expressed concerns that computer-assisted instructional programmes would interfere with the traditional student–teacher encounter and relationship.[8] More recently, Triola *et al.* showed student acceptance for virtual, as opposed to simulated, patients as estimated by subjective ratings by students.[9]

As Devitt and Palmer pointed out, if computer materials are to be provided as a learning resource they must be made suitable for the style of teaching of the course.[10] Twenty-three of 26 students (88%) said they would prefer to receive CBL prior to BT. This

is a strong finding and was as common amongst the students who did not experience the teaching in this order as it was amongst those who did. Fortunately, both the strongly held students' views concur with the objective evidence: that the best learning outcomes are obtained when both teaching methods are employed, with CBL followed by BT.

CONCLUSIONS

In conclusion, we think we have learned something useful about how to best integrate CBL into our musculoskeletal clinical examination session. Computer-based learning is not a replacement for BT, but, rather, a useful adjunct which improves learning. As constructivist theories of learning would suggest, educators must take care to provide a foundation of knowledge on which clinical experiences can be built. Objectively, CBL followed by BT represents the optimal sequence of delivery and this was the overwhelming subjective preference of the students in our study.

Contributors: PH designed the trial, made the teaching video, ran the teaching programme and collected and analysed the statistical data. AC contributed to the trial design, teaching session and data collation and drafted the initial paper. AP contributed to the trial design, teaching session and data collation. GP contributed to the trial design and teaching session. All authors contributed to editing the paper and approved the final manuscript for publication.
Acknowledgements: Dr Nicholas Parsons, University of Warwick, is acknowledged for his help with statistical analysis.
Funding: none.
Conflicts of interest: none.
Ethical approval: University Hospital Coventry and the Warwickshire Research Ethics Committee decided that ethical approval was not required.

REFERENCES

1 Xeroulis GJ, Park J, Moulton C, Reznick RK, LeBlanc V, Dubrowski A. Teaching suturing and knot-tying skills to medical students: a randomised controlled study comparing computer-based video instruction and (concurrent and summary) expert feedback. *Surgery* 2007;**141** (4):442–9.
2 Cook DA. The research we still are not doing: an agenda for the study of computer-based learning. *Acad Med* 2005;**80**:541–8.
3 Friedman C. The research we should be doing. *Acad Med* 1994;**69**:455–7.
4 Clark R. Dangers in the evaluation of instructional media. *Acad Med* 1992;**67**:819–20.
5 Bransford J, Johnson MK. Contextual prerequisites for understanding. *J Verbal Learn Verbal Behav* 1972;**11**:717–26.
6 Percival F, Ellington H, Race P. *Handbook of Educational Technology*, 3rd edn. London: Kogan 1993;17.
7 Ridgway PF, Sheikh A, Sweeney KJ, Evoy D, McDermott E, Felle P, Hill AD, O'Higgins NJ. Surgical e-learning: validation of multimedia web-based lectures. *Med Educ* 2007;**41** (2):168–72.
8 Steele DJ, Johnson P, Jodi E, Lynch TG III, Lacy NL, Duffy SW. Learning preferences, computer attitudes, and student evaluation of computerised instruction. *Med Educ* 2002;**36** (3):225–32.
9 Triola M, Feldman H, Kalet AL, Zabar S, Kachur EK, Gillespie C, Anderson M, Griesser C, Lipkin M. A randomised trial of teaching clinical skills using virtual and live standardised patients. *J Gen Intern Med* 2006;**21**:424–9.
10 Devitt P, Palmer E. Computer-aided learning: an overvalued educational resource? *Med Educ* 1999;**33** (2):136–9.

SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Figure S1. The objective structured clinical examination.

Figure S2. The feedback form.

Please note: Wiley-Blackwell is not responsible for the content or functionality of any supporting materials supplied by the authors. Any queries (other than for missing material) should be directed to the corresponding author for the article.

Received 15 December 2007; editorial comments to authors 27 June 2008; accepted for publication 2 September 2008