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Computer-aided Learning (CAL): an effective way to teach the Index of Orthodontic Treatment Need (IOTN)?

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Abstract

Objective: To identify if a lecture or access to a computer aided learning (CAL) programme is more effective in teaching undergraduate dental students IOTN.

Design: Prospective controlled trial.

Setting: University Dental Hospital of Manchester, 1999

Subjects: Eighty-five 3rd year undergraduate dental students allocated by pseudo-randomisation to two groups. The first group received a lecture and seminar on IOTN, and the second group were given a seminar and access to a purpose written CAL programme.

Main Outcome Measure: A standard test was given to the two groups in the form of ten sets of patient records that they had to score with IOTN Dental Health Component (DHC) and Aesthetic Component (AC).

Results: There was no difference in mean score for the two groups with AC score (5·02 and 5·03). The CAL group of students performed best for DHC grade (mean score 5·41 compared with 4·24 for lecture group) and this was statistically significant ($p < 0.01$).

Conclusion: Undergraduate dental students can learn to use IOTN as well or better when using a CAL programme compared with a lecture.

Index Words: Computer aided learning, IOTN, Teaching method, Undergraduate

Introduction

In this study we assess the effectiveness of a Computer-aided Learning (CAL) package for teaching the Index of Orthodontic Treatment Need (IOTN) to undergraduate dental students. If CAL is effective in this setting it could be a valuable aid in orthodontic teaching.

The development of the personal computer and the computerization of many routine tasks have had a profound effect on all of our lives. For example, in 1996–97, 26·7 per cent of the population of the United Kingdom had access to at least one home computer (Office of National Statistics/Government Statistical Service, 1999a). Furthermore, in education, secondary schools had an average of 101 computers per school in 1998. This was the equivalent of one computer for every nine pupils (Office of National Statistics/Government Statistical Service, 1999b).

In the field of education, computerization has enabled the development of teaching/learning packages and computer-aided learning (CAL) has become widely accepted in education as a useful means of acquiring knowledge (Boyd, 1997). Recently, the development of relatively inexpensive powerful computers has enabled CAL to incorporate many more illustrations, photographs, interactive material, and even videos. This multimedia aspect should make some aspects of all CAL packages appeal to everyone. However, in an early report on the acceptability to undergraduates of a computer-aided learning package on orthodontics compared to usual teaching methods (Stephens and Dowell, 1983) 30 per cent of students preferred the computer, 45 per cent preferred to discuss the problem with a staff member, and 14 per cent had no preference. The authors concluded that CAL was 'significantly more popular than private study but significantly less popular than small-group teaching'.

The effects of CAL in education and medicine have been studied extensively. For example, a meta-analysis on the effectiveness of computer-based college teaching was undertaken by Kulik *et al*. in 1980. This revealed that there was an average increase in examination score of 3 per cent with CAL. The use of CAL also significantly reduced the time required to teach the subject matter.

Another meta-analysis by Cohen and Dacanay (1992) investigated the use of CAL in educating health professionals. Their aims were to identify those studies where comparisons were made between individualized instruction (CAL) and conventional instruction. Thirty-two of the 47 studies included in the analysis indicated that CAL resulted

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in students having a higher average examination result. In 14 studies there were statistically significant differences between CAL and conventionally taught students. Significantly, 13 of these favoured CAL, portraying a relatively strong advantage for CAL.

There have been few published reports of the efficacy of CAL in the dental teaching setting, and these are listed in Table 1. In a further meta-analysis Dacanay and Cohen (1992) analysed individualized instruction (CAL) in dental education. They found only four reports of computer-based packages that could be included in the meta-analysis and three of these showed large achievement gains. The exception was Hobson *et al.* (1998) who investigated CAL when compared to a tutorial on orthodontic assessment and treatment planning. The results indicated that the students taught by the conventional tutorial made a significantly greater gain than those taught by CAL. The students also felt that the presence of a member of staff at the CAL session to provide answers to any queries might have maximized the benefits of this teaching method.

It appears from the literature that CAL may be an effective method of teaching well-defined concepts concerning one aspect of the curriculum. We decided that an ideal subject for investigation would be the Index of Orthodontic Treatment Need (IOTN), which is a well established occlusal index that is used to measure orthodontic treatment need (Brook and Shaw, 1989).

Subjects and methods

Subjects

Undergraduate dental students at Manchester Dental School are allocated to eight separate teaching groups, with every eighth student alphabetically being allocated to each group. These groups are then numbered from 1 to 8. The evenly numbered groups were the first to commence their orthodontic module and were allocated to the control group. This group consisted of 26 females and 20 males. The odd-numbered groups were allocated to the study group. This consisted of 19 female and 20 male students.

Methods

The control group received the normal orthodontic teaching on IOTN provided at this stage of the undergraduate course. This consisted of one lecture, followed by one tutorial. One week later, the control group then underwent the test. The CAL package was not available whilst the control group were undergoing teaching, so these students were unable to acquire knowledge via this source. The study group was excluded from the lecture and were allocated to the CAL package plus one tutorial.

The CAL package was written, using an Internet web-authoring package, by one of the authors (CIL), and was of a multimedia design with didactic, interactive, and video components. These different multimedia types of teaching/learning material were used to appeal to students who may prefer to assimilate information in different ways. In addition, there was the opportunity for the students to assess their own performance through practical exercises. However, some students may still find the CAL package inadequate for their purposes and, therefore, no restrictions were placed on any students from seeking information from other sources. The students in the study group were timetabled to spend 1 hour using the CAL package. They were also able to access the package at other times should they wish to. The study group underwent the test one week later.

Test material

The test material consisted of 10 sets of study models that were selected to provide a wide range of cases in IOTN groups 4 and 5. These grades were chosen as these were the most commonly used grades and had the clearest definitions. These models were used to test the students' application of the dental health component of IOTN. There were also 10 photographs, also selected to provide a wide range of malocclusions, which were to be used to test the application of the aesthetic component. The models and photographs were graded by two examiners, calibrated for IOTN, so that a 'gold standard' could be obtained. If there was any disagreement on the IOTN scoring for either the models or the photographs then these were excluded and replaced with an alternative.

TABLE 1 *Published reports on the effectiveness of CAL in a dental setting*

Authors	Subject	Participants	Study size	Conclusions
Stephens and Dowell (1983)	Orthodontics	Undergraduates	43	All students improved using CAL
Luffingham (1984)	Orthodontics	Undergraduates	60	Mean scores statistically significantly higher with CAL
Irvine and Moore (1986)	Mixed dentition analysis	Undergraduates	52	Scores statistically significantly higher with CAL
Levine *et al.* (1987)	Dental caries Periodontitis.	Undergraduates	60	CAL and tutorials equally effective
Turner and Weerakone(1993)	Cephalometrics	Undergraduates	16	CAL and tutorials equally effective.
Long *et al.* (1994)	Orthodontics, biopsies, Surgical endodontics.	GDPs	45 50	Participants reported definite knowledge gain.
Pollard and Davenport (1994)	Partial denture design	GDPs	65	Participants reported definite knowledge gain.
Clarke *et al.* (1997)	Cephalometrics	Undergraduates	52	No statistically significant difference between lecture and CAL groups.
Downes and Eaton (1997)	Cross-infection control	GDPs and 'experts'		Knowledge gain reported by CAL groups.
Hobson *et al.* (1998)	Orthodontic treatment planning	Undergraduates	49	Tutorial better than CAL.
Bachman *et al.* (1998)	Oral anatomy	Undergraduates	85	No statistically significant difference between lecture and CAL groups.

The models were placed in ten different locations and the photographs were divided into sets of five and placed at a further two locations, making 12 locations in all. The students were allowed one minute 30 seconds at each location in which to assess either a set of study models or five photographs.

Students were asked to assess both the grade and identifying descriptorof the DHC for each set of study models and the aesthetic component for each photograph.

Sample size calculation

No data was available for undergraduate students' performance in IOTN testing following lecture and CAL teaching. Assuming a mean score of five correct answers, using the standard deviation of 1·5 obtained from IOTN calibration courses, to detect a difference in mean score of 1 correct answer with a power of 0·8 and statistically significant at the 0·05 level required two groups of 37 subjects.

Statistical methods

The test data were analysed using the Statistical Package for Social Sciences for Windows® (SPSS for Windows®). *t*-tests were used to compare the students' scores between the two groups. Logistic regression models were used to identify factors that improved test scores.

Results

Eighty-five students participated in this study. Forty-six students were in the control group (lecture) and 39 were in the study group (CAL). The results for the number of students getting each question correct are shown in Table 2.

Total mean scores for AC and DHC are shown in Table 3. *t*-tests showed no difference in mean scores between the two groups for AC, but for all aspects of DHC, the mean score for the study group is higher than that of the control group. This difference is greatest for the assessment of DHC grade ($P < 0{\cdot}01$).

The logistic regression models, shown in Table 4, showed a difference in mean scores for different questions and when study group was added to the model this was also significant. No interaction between question and study group was found. This means that the difference between the two groups was consistent across questions with the CAL group performing better than the lecture group. It was not the case that one group did better at some types of questions and the other group at others.

Discussion

We chose the methodology in this study to reflect current teaching practices. Therefore, the lecture group received their normal teaching and could carry out whatever additional study they wished. However, it was essential that they did not have access to the CAL package and this was, therefore, withheld at this stage. After this control group had been tested, the CAL students were allocated 1 hour to use the IOTN package as part of their normal timetable. Importantly, they were encouraged to use the package at other times if they wished to do so. If they chose not to, then that was their free choice and was a reflection of the real world. Similarly, if they still wished to access the information elsewhere, then that was also their free choice. On the same basis no record was made of the amount of time spent by individuals in using the IOTN programme. This reflects the importance of recognizing the totality of the learning experience and the context in which it lies. By incorporating the CAL into a teaching package the students were able to use it individually or as groups, and allowed the users to

TABLE 3 *Mean scores for Aesthetic Component and Dental Health Component for each group*

	Group	Mean	SD	*P*
AC	Control	5·02	1·74	
				0·991
	Study	5·03	1·40	
DHC grade	Control	4·24	1·69	
				0·002
	Study	5·41	1·70	
DHC qualifier	Control	3·04	1·73	
				0·089
	Study	3·64	1·42	
DHC grade and qualifier	Control	2·50	1·67	
				0·055
	Study	3·18	1·52	

Control group $n = 46$; study group $n = 39$.

TABLE 2 *Number of students getting the correct answer for each component of IOTN for the 10 questions*

	Aesthetic component		DHC grade only		DHC qualifier only		DHC grade and qualifier	
Question number	Control group	Study group	Control group	Study group	Control group	Study group	Control group	Study group
1	27	17	33	29	34	34	29	29
2	26	20	1	2	1	2	1	2
3	26	19	13	20	10	12	9	12
4	37	31	4	8	4	8	4	8
5	14	18	39	31	27	17	27	15
6	14	23	20	26	5	9	1	7
7	44	23	28	29	29	28	22	25
8	16	13	20	28	15	15	11	13
9	18	9	13	13	3	2	1	1
10	9	10	24	25	12	15	10	12

Control group $n = 46$; study group $n = 39$.

TABLE 4 *Results of logistic regression analysis of correct DHC answers: CAL compared to lecture*

Dependent variable	Significance of group	Exp (B) (Study compared to control)	95% CI of Exp (B)	
			Lower	Upper
DHC grade only correct	0·0001	1·8628	1·3597	2·5518
DHC qualifier only correct	0·0312	1·4484	1·0340	2·0289
DHC grade and qualifier correct	0·0127	1·5482	1·0979	2·1830

Chi squared test for DHC

		Both correct	Grade correct	Qualifier correct
Step 1-Question	Chi squared	208·358	227·539	246·581
	Significance	0·0000	0·0000	0·0000
Step 2-CAL	Chi squared	6·257	15·28	4·666
	Significance	0·0124	0·0001	0·0308

work at their own pace, taking as much time as they wished, to meet their own individual needs.

Examination of the answers provided for DHC leads to some interesting findings. The worst results for both groups were for questions 2 and 4. Interestingly, both of these study models were graded IOTN 5i. Clearly, the students had difficulty with this IOTN category and it is an area that should perhaps have more time devoted to it in teaching sessions. Since IOTN grade 5i is often associated with impacted canines, and since these can be very difficult to treat, it is essential that students are able to recognize this IOTN category and to seek orthodontic advice.

For the AC of IOTN there was no difference between the groups with mean scores of 5·02 for the control group and 5·03 for the study group. It should also be remembered that an answer that was within 1 of the designated answer would result in the answer being scored as correct. Where the photographs represented the extremes of the AC range, question 4 (AC = 9) and question 7 (AC = 1), it was reassuring that most students provided correct answers. Since the AC is a very subjective measure it is, perhaps, understandable that the teaching method used made little difference. It is also simpler and is therefore easier to teach conventionally. Whichever teaching method is used it is still really a matter of the individual's perception of the aesthetic appearance of the malocclusion.

Importantly, for all aspects of the DHC of IOTN this study confirmed the findings of Kulik *et al.* (1980), and Cohen and Dacanay (1992) who had shown that CAL students produced higher mean scores than those produced by conventional teaching methods. The teaching of DHC is a different matter to the teaching of AC as there are several distinct aspects to DHC. As well as needing to know the various grades, the student must also understand the qualifying categories and their application to a malocclusion. This can be discussed briefly in a lecture, but if the student is able to return repeatedly to this aspect of IOTN, as they can in the CAL package, then it seems that the concepts of DHC are reinforced.

The results of this study have shown that CAL is statistically significantly better than a lecture for the teaching of all aspects of the DHC of IOTN. This is in agreement with the findings of Luffingham (1984), and Irvine and Moore (1986), who showed that CAL was better than conventional teaching and that these differences were statistically significant. The only other study on the use of CAL to teach IOTN was the MSc thesis published by Jones (1992). She compared the teaching of IOTN by CAL, videotape, and a booklet, and found no differences between the three methods. However, the sample sizes were small and the methods used to obtain volunteers may have led to some selection bias. Additionally, the computer package designed by Jones was limited by the power of the computers available at the time. Because of the power of modern computers it was possible to incorporate all of the types of media used by Jones in the CAL programme used in this study, and it is possible that this enhanced its usability and effectiveness.

Whilst the results show that CAL is statistically significantly better than a lecture for teaching IOTN it is also important that the clinical significance of this is looked at. It was found that belonging to the CAL group increased the odds of getting a correct score for DHC grade by a factor of 1·86.

The future

CAL provides several interesting teaching possibilities. As the pressure on academic teaching staff increases, CAL may be a cost-effective way of imparting new knowledge. This is confirmed by research, which has consistently demonstrated that CAL is at least as good as conventional teaching and, sometimes, better. The cost in man-hours in the development of a multimedia CAL package will be more than compensated for by the eventual time-savings achieved in freeing academic staff to do other jobs. It is important to remember that the lecture or CAL was not the sole teaching method in this study, but in conjunction with a seminar, and that the CAL was available for the students to use as they wished. Care should be taken to ensure that CAL is not used exclusively, but as an adjunct, and certainly could replace formal lectures.

This study has demonstrated that CAL has a definite place in the teaching of IOTN. However, it will also be useful as a revision aid. Students who have a working baseline of IOTN will be able to fine-tune their knowledge of its application and uses.

For orthodontists and general dental practitioners a working knowledge of IOTN is becoming increasingly

important. As the 'gatekeepers' to orthodontic treatment GDPs need to be aware of their referral pathways and any restrictions imposed upon them (Bearn *et al*., 1996). Many hospital departments already restrict orthodontic treatment to IOTN grades 4 and 5 (Holmes and Willmot, 1996). It is of no benefit to the patient or to the hospital referral centre to receive referrals of patients with lower IOTN grades, since this inconveniences the patient and takes up surgery time. Clearly, it is becoming an increasing priority that dentists have a good working knowledge of IOTN and its application. Although IOTN courses are useful (Richmond *et al*., 1995) it is not feasible to provide courses for everyone. A CAL package to teach IOTN could therefore be an invaluable method of distributing the relevant information to those most needing it.

An improved knowledge of IOTN should ensure that the 'gatekeepers' are able to function properly with patients being directed to the most relevant specialist centre. This will reduce the number of inappropriate referrals, save time and cost to the referral centre and, importantly, also save time and cost for the patient.

Conclusions

1. CAL is as effective as a lecture for teaching AC of IOTN.
2. CAL is more effective than a lecture for teaching DHC of IOTN.
3. CAL allows its user to return repeatedly to study any concept that they may not fully grasp and this may contribute to a better understanding.

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