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Original Research

Effect of linear versus adaptive electronic continuing medical education regarding dental bleaching on dentists' knowledge and satisfaction

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Abstract

Background: Studies on the efficacy of adaptive e-learning in dentistry are limited. This study aimed to compare the efficacy of linear and adaptive electronic continuing medical education (CME) courses about dental bleaching.

Methods: This quasi-experimental study using a post-test control group design evaluated the efficacy of an electronic CME course on dental bleaching offered to 60 dentists who were non-randomly allocated in two linear and adaptive groups (n=30). One training session was held for participants of both the intervention and the control groups. At the end of the course, the learners participated in a post-test and completed a satisfaction questionnaire. SPSS 23 was used to analyze the results. An independent t test was used to assess the effect of type of intervention on the outcome of education, and Pearson's chi-square test was applied to assess the effect of the intervention on participants' satisfaction.

Results: The mean post-test scores of participants were 6.33±1.47 for the linear group and 6.40±2.31 for the adaptive group. The mean satisfaction scores of participants were 4.02±0.53 for the linear group and 4.15±0.42 for the adaptive group. According to an independent t-test, the two groups were not significantly different in terms of post-test score ($P=0.7$) or level of satisfaction ($P=0.2$).

Conclusion: The adaptive approach has considerable advantages and comparable efficacy to the linear method in terms of post-test score and self-reported knowledge and satisfaction of participants. Thus, this method of education may be as effective as the linear method for instruction in dental bleaching. The use of an adaptive approach is therefore recommended in educational curricula.

Introduction

Continuing medical education (CME) courses are imperative for graduates to maintain their professional skills. Undergraduate and postgraduate university education cannot guarantee the maintenance of skills throughout the professional life of a physician or dental clinician since the half-life of knowledge has become very short as a consequence of the information explosion.[1-3] Dental education is a lifelong, continuous process and a professional and ethical obligation that will last until the end of a dentist's professional life. Dental clinicians are responsible for enhancing their level of knowledge and skills by participating in CME programs.[4]

A beautiful smile is highly influenced by the color, shape, and position of teeth.[5] Thus, correction of discolored, mal-shaped and crowded teeth often improves patients' self-esteem, quality of life, and social communication.[6] The current demand for correction of tooth discolorations and whitening of teeth is high.[6] Considering the popularity and profitability of such esthetic treatments, inadequate programming concerning CME courses on these topics could result in malpractice, or dental clinicians may seek knowledge from unreliable sources. One strategy includes educational programming for CME courses for general dentists.

The literature emphasizes the need for assessment of the efficacy of CME courses.[7, 8] However, the results of studies around the efficacy of electronic CME courses are widely debated.[9,10] The incidence of e-learning for dental education has dramatically increased due to its advantages

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such as easy access, freedom of navigation, high quality of medical images, and repeatability.[11] Web-based education is a crucial tool in evidence-based medical education due to its ability to be kept up to date.[11] According to qualitative studies, e-learning is well accepted in medical education.[12] Since the introduction of e-learning in dentistry in the 1970s,[13] its application has been continuously on the rise. The balance between traditional learning and electronic instruction depends on the educational goals, qualities of the learners, availability of online sources and instructor experience.[14]

Riad et al stated in 2009 that although learners are satisfied with electronic learning since they are no longer bound by the location and time of learning, promotion of learning in this method is a matter of question.[15] One consideration around e-learning and the promotion of learning with this tool is to pay attention to the interests and preferences of the learners/users to customize the learning process.[16] This approach led to the development of adaptive e-learning as an alternative to a conventional, linear "one-size-fits-all" learning method. In the adaptive learning approach, a model is provided according to the learner's objectives, level of knowledge, interests, and preferences, and the learning process is guided to meet these requirements.[17]

In his study in 2014 on the future of e-learning in medical education, Walsh stated that e-learning will be more adaptive in the future and will be offered to address the needs of learners more precisely.[18] A 2010 study predicted that adaptive e-learning would increase the success and efficacy of learning.[19] However, also in 2010, Vandewaetere et al stated that despite advances in technology and education which resulted in highly efficient personalized learning, adaptive e-learning still has shortcomings around the applicability and adequacy of technology for learning. Moreover, they stated that some concerns existed regarding interactions between technologically-reinforced learning and compatibility.[17] Moreover, data collection to produce an exclusive model for inclusive learning and its application in adaptive learning may not be feasible.[20]

On the other hand, some instructors need to spend a great deal of time learning some adaptive learning models.[20] In contrast to linear models where learners follow a specific and non-flexible path, designing non-linear learning environments is highly complex.[21] One major shortcoming of adaptive systems is their inflexibility, which makes it impossible to combine them with the currently available learning management systems; moreover, course content is not reusable.[21]

The CME website of the Tehran University of Medical Sciences, available at https://education.tums.ac.ir, has been designed according to the principles of electronic learning. This website provides electronic CME courses to the medical community according to their needs and the scientific pattern of e-learning(https://education.tums.ac.ir).This website provides linear continuing education courses via student interaction with content. Since the infrastructure of this website allows the provision of electronic content in a non-linear (adaptive) manner, and considering the advantages and shortcomings of adaptive e-learning and the need for further studies on this topic, it seemed crucial to compare the efficacy of linear and adaptive approaches. Thus, this study aimed to compare linear and adaptive CME courses on dental bleaching on dentists' knowledge and satisfaction as they participated in online CME courses offered by the Tehran University of Medical Sciences.

Materials and Methods

This quasi-experimental study using a post-test control group design assessed the efficacy of linear and adaptive e-learning approaches employed by a CME website at the Tehran University of Medical Sciences for an online course in bleaching single discolored teeth. The website is available at https://education.tums.ac.ir. The knowledge and level of satisfaction among dentists using this service were evaluated and compared. The study population was comprised of general dentists participating in an online CME course available on the CME website of Tehran University of Medical Sciences at https://education.tums.ac.ir on bleaching single discolored teeth.

Taking into consideration a standard deviation of 2, study power of 20%, and 5% level of significance, 29 samples were necessary in each group to detect 1.5 points of difference between the two groups.

The inclusion criteria were as follows: Every dentist who participated in the electronic bleaching course. Exclusion criteria: History of participation in an educational program or workshop on this topic (asked in the satisfaction questionnaire).

Compilation of the educational content in the CME website was performed by discussing the topic (disease/condition and its follow up) through questions and answers. The educational content of the course was compiled according to the educational goals of the curriculum regarding the bleaching of single discolored teeth in the form of questions and answers. The program had five major areas that met the educational goals, outlined as follows.

1. Study guide: In this part, learners were familiarized with the program. This included the target population, the acquired score upon completion of the course, the price of the program, name and information of authors, program objectives, and a brief introduction about the course.
2. Texts: The texts in the program included scientific descriptions, an introduction of patients or problems, and resources and references discussed in the scenario.
3. Program questions: Multiple-choice questions with

four possible responses were designed. Questions within the course were designed according to the objectives of the program and key points. In fact, these questions followed a goal and had the highest educational load for the participants.

4. Arrangement of the scenario for texts and questions: Both linear and adaptive approaches were applied for the two study groups.
5. Assessment of the program: The final version of the program was assessed by the website manager, and the writers of the programs were provided with feedback.

The educational content was accessible to all. Dental clinicians participated in the CME program after signing up for the course.

In the linear approach, which is the conventional approach on this website, the educational goals–including correct diagnosis, treatment planning, instruction of patient, bleaching techniques, treatment complications, factors affecting the treatment and alternative methods to bleaching– were compiled in a scenario and the learner attains the educational goals by answering a series of questions. In the current study, participants in the linear method reviewed 16 questions and answers, which were the same for all participants in this group.

For the adaptive method, the same content was provided in small packages that were related to each other with specific logic, and learners could navigate among these packages according to their level of previous knowledge. The learners could pass the course according to their previous knowledge and at their desired speed. The arrangement of this adaptive program was such that a different path of learning would be provided for the learner depending on giving a correct or incorrect answer to each question. Thus, each participant, according to his/her level of previous knowledge, could pass the course by answering a minimum of 10 and maximum of 26 questions and answers.

Both the linear and adaptive programs were uploaded to the website. The linear program was uploaded first, and after reaching the required sample size, the same content was offered but this time using the adaptive approach. A post-test was given at the end of the course for each participant, and the participants also completed a satisfaction questionnaire (Figure 1). It should be noted that both groups acquired the score allocated after completion of the course.

Data collection tool

A researcher-designed questionnaire in two parts was used to collect the data. At the onset of the study and after complication of the topic, 10 questions were designed given for the post-test according to the educational goals, blueprint of the test, and previous studies. To assess the validity of the test, ten restorative dentists were consulted, and the content was modified accordingly using the Delphi method. In order to assess the content validity of the questionnaire in its quantitative form, content validity ratio (CVR) and content validity index (CVI) were used. Ten dental professors with different specialties were asked to classify each question based on a three-part range of "Necessary", "Useful but unnecessary," and "Unnecessary". Their responses were then calculated based on the CVR formula. To calculate the CVI, three criteria of simplicity, relevance, and clarity were scored separately using a 4-point Likert scale (1 = Unrelated, 2 = Somewhat related, 3 = Related, and 4 = Fully related) by 10 dental specialists.

The CVI score was calculated by adding the approximate scores for each item divided by the total number of dental specialists. If the score of each item based on the CVI score was greater than 0.78, the item was approved. To assess the reliability of the test, the Kuder-Richardson formula was used, and the alpha coefficient was calculated to be 0.80, which established the reliability of the test.

The second part of the questionnaire included satisfaction questions, which included 11 questions on satisfaction with the method of instruction and self-reports about obviating the occupational needs and improved performance.

SPSS 23 was used to analyze the data, reported using descriptive statistics (mean and standard deviation), and inferential statistics such as t-test and chi-square test.

Following the study, participants in group 1 (linear

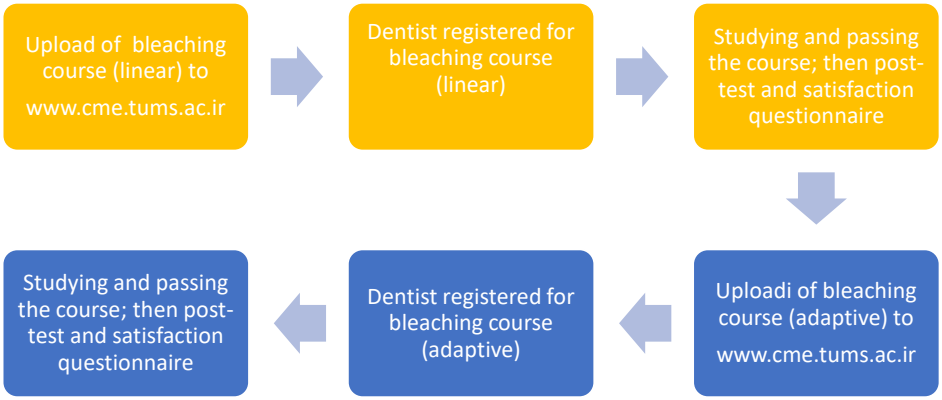

Figure 1. Flowchart of the procedure of the educational content and compilation of the two methods.

approach) were informed that they could take the adaptive version of the course via text message.

Results

Demographic characteristics

Of 30 participants in the linear group, 15 (50.0%) were male and 15 (50.0%) were female; 11 (36.7%) were working in Tehran, and 19 (63.3%) were working in other cities; 5 (16.7%) were working in the public sector, and 17 (56.7%) were working in the private sector [where were the other 8 working?].

Of the 30 participants in the adaptive group, 12 (40.0%) were female and 18 (60.0%) were male; 15 (50.0%) were working in Tehran, and 15 (50.0%) were working in other cities; 1 (3.3%) was working in the public sector, and 11 (36.7%) were working in the private sector [where were the other 16 working?].

Table 1 shows the mean post-test scores and Table 2 shows the mean satisfaction scores of participants for the two groups based on the 4-point Likert scale. Data were not normally distributed in the two groups according to the kurtosis and skewness values and the results of the normality test using the Shapiro-Wilk test ($P=0.038$ and $P=0.015$ for the linear and adaptive groups, respectively). Thus, non-parametric tests were used for the statistical analysis.

Table 3 shows different domains of satisfaction of participants in the two groups with the instruction approach according to the chi-square test at 0.05 level of significance.

Discussion

The current results revealed that adaptive e-learning for the instruction of bleaching of single discolored teeth was as effective as the conventional linear approach in terms of learning outcome (indicated by the post-test score) and level of satisfaction of learners (self-reported by participants). This finding was in line with the results of AlTaaban et al,[22] who compared pre-test and post-test scores of two groups of students who received linear and adaptive approaches for digital storytelling and concluded that both of these methods of distance education improved knowledge acquisition and creative thinking skills. On the other hand, Katuk and Zakaria compared linear and non-linear navigation in terms of educational content and their effects on engagement in network-based instruction and found that the type of navigation (linear/non-linear) had different effects on different aspects of engagement.[23]

Table 1. Mean post-test scores of participants in the two groups (N = 60)

Group	Mean and standard deviation	Mean rank	Mann Whitney U test	*P* value
Linear (n = 30)	6.33 ± 1.47	27.1	353.000	0.391
Adaptive (n = 30)	6.40 ± 2.31	30.8		

Table 2. Mean satisfaction score of participants in the two groups (n = 30)

Group	Mean and standard deviation	Mean rank	Mann Whitney U test	*P* value
Linear	4.02 ± 0.53	25.6	310.000	0.124
Adaptive	4.15 ± 0.42	32.3		

The level of satisfaction (using a Likert scale) of learners with both methods of instruction was high in our study (4.02 ± 0.53 in the linear and 4.15 ± 0.42 in the adaptive group). This may be due to ease of e-learning via the CME website. Learning via this website does not require specific computer skills or programs (such as PowerPoint, Word, or Excel), and it is easily usable by learners who may have limited familiarity with the Internet. According to Buckley,[24] easy access to educational content via a computer can increase the learning efficacy of learners. Attractiveness and applicability of the educational topic are also crucial in learner satisfaction with the method of instruction.

The CME website of the Tehran University of Medical Sciences (https://education.tums.ac.ir) provides the medical community with CME programs according to their requirements. This website enables communication between the learner and the electronic educational content; learning occurs independently in this environment. However, some critics believe that individual computer-based educational approaches are strict, mechanical, and inhuman since there is no interaction and communication between the mentor or instructor, students, or peers.[25] However, the high level of learner satisfaction in our study indicates that dentists seem to prefer this method of instruction, perhaps due to their busy schedule. The educational content uploaded into the CME website has to date been linear; in other words, the path of instruction and learning is determined by the educational programmer, and the learner has no control over the path of learning according to his/her individual preferences.

On the other hand, the adaptive approach enables compilation of the educational content according to learners' level of previous knowledge. Some researchers believe that learners have less risk of making mistakes in the linear approach,[26] and the risk of confusion using a linear approach is lower in learners who have a lower level of previous knowledg.[27] However, Baylor found that linear methods could cause further confusion in learners.[28] In the current study, the self-reported satisfaction of learners with "clarity of the presented content" and "logical order and sequence of topics" was high for both the linear and adaptive approaches, which seems to indicate that both approaches are user-friendly and did not cause confusion among participants.

In the current study, each participant passed the course by reviewing 16 questions and answers in the linear group and a minimum of 10 and a maximum of 26 questions and answers in the adaptive group. Previous studies have found that taking into account the previous knowledge of learners is one strategy to change the linear approach

Table 3. Satisfaction of participants in the two groups with the instruction approach according to the chi-square test

No.	Questions	Group	Answers, No. (%)						*P* value
			Totally agree	Agree	No comment	Disagree	Totally disagree	No answer	
1	This program obviated your occupational needs.	Linear	10 (33.3)	17 (50.7)	2 (6.7)	0 (0)	1 (3.3)	0 (0)	0. 00
		Adaptive	18 (60.0)	12 (40.0)	0 (0)	0 (0)	0 (0)	0 (0)	
2	The program objectives were clear and in accord with your occupational needs.	Linear	9 (30.0)	17 (56.7)	4 (13.3)	0 (0)	0 (0)	0 (0)	0.14
		Adaptive	12 (40.0)	17 (56.7)	1 (3.3)	0 (0)	0 (0)	0 (0)	
3	The educational content covered the program goals.	Linear	8 (26.7)	16 (53.3)	5 (16.7)	1 (3.3)	0 (0)	0 (0)	0.57
		Adaptive	11 (36.7)	16 (53.3)	3 (10.0)	0 (0)	0 (0)	0 (0)	
4	The content of the program was scientifically up-to-date.	Linear	7 (23.3)	17 (56.7)	6 (20.0)	0 (0)	0 (0)	0 (0)	0.27
		Adaptive	11 (36.7)	16 (53.3)	2 (6.7)	0 (0)	0 (0)	0 (0)	
5	The scenario of the program followed a logical path and sequence.	Linear	9 (30.0)	14 (46.7)	6 (20.0)	1 (3.3)	0 (0)	0 (0)	0.60
		Adaptive	12 (40.0)	14 (46.7)	4 (13.3)	0 (0)	0 (0)	0 (0)	
6	Proper feedback was given to your answers.	Linear	6 (20.0)	18 (60.0)	4 (13.3)	1 (3.3)	0 (0)	0 (0)	0.54
		Adaptive	10 (33.3)	17 (56.7)	2 (6.7)	0 (0)	0 (0)	1 (3.3)	
7	Presentation of content was clear.	Linear	8 (26.7)	14 (46.7)	6 (20.0)	2 (6.7)	0 (0)	0 (0)	0.43
		Adaptive	9 (30.0)	17 (56.7)	4 (13.3)	0	0 (0)	0 (0)	
8	Films and images were of optimal quality.	Linear	4 (13.3)	16 (53.3)	6 (20.0)	2 (6.7)	0 (0)	0 (0)	0.18
		Adaptive	5 (16.7)	14 (46.7)	8 (26.7)	0 (0)	0 (0)	2	
9	Images and other attachments were used as appropriate.	Linear	4 (13.3)	16 (53.3)	6 (20.0)	4 (1.33)	0 (0)	0 (0)	0.70
		Adaptive	6 (20.0)	11 (36.7)	7 (23.3)	4 (13.3)	0 (0)	0 (0)	
10	The topic was interesting.	Linear	9 (30.0)	18 (60.0)	3 (10.0)	0 (0)	0 (0)	0 (0)	0.19
		Adaptive	13 (43.3)	15 (50.0)	0 (0)	1 (3.3)	1 (3.3)	0 (0)	
11	This program enhanced your professional skills.	Linear	8 (26.7)	19 (63.6)	3 (10.0)	0 (0)	0 (0)	0 (0)	0.42
		Adaptive	12 (40.0)	14 (46.7)	4 (13.3)	0 (0)	0 (0)	0 (0)	

*Significance level $P<0.5$

to an adaptive approach.[29,16] In aptitude-treatment interaction, adaptive learning and learner control over the scenario content can be partial or complete and the speed of learning can be controlled by the learner.[29,30] In the adaptive method provided on the CME website of the Tehran University, the learners could choose a different path of learning at their own desired speed according to their level of previous knowledge and quality of their responses. However, learners cannot be monitored during the process, which is one limitation of this approach.

The results of the current study showed that learners in the experimental (adaptive) group had identical scores as learners in the control (linear) group. Fatahi [30] found that students using an adaptive e-learning environment (experimental group) scored higher than others (control group). In Fatahi's study, students also expressed that the adaptive e-learning environment was more attractive and matched with their personality traits. Personality and emotion were not evaluated in our study, which is an area to evaluate in future studies using adaptive courses on the CME website of the Tehran University of Medical Sciences.

Considering the reinforcement limitations of educational research, this study was designed with a quasi-experimental design since random allocation of learners to the two groups was not possible. Due to the possibility of "pretest sensitization" bias, this study had an interventional post-test control group design, and only the post-test and satisfaction scores of the two groups were compared. Thus, those with a previous history of participation in a similar course or workshop and participants who had studied the educational content before their participation were not included.

On the other hand, since classroom-based CME courses require allocation of time and a specific location to hold the classes, it may be essential to design, implement, and assess electronic CME programs on different topics as an adjunct to classroom-based instruction.

Last but not least, considering the current needs of the dental community to assess challenges and foresee the future of e-learning and electronic CME and their feasibility based on the available resources, the results of this study may help pave the way to achieve these goals.

Conclusion

Considering the advantages of the adaptive approach and its comparable efficacy to that of the linear method in terms of post-test scores and self-reported knowledge and satisfaction of participants, this method of education may be as effective as the linear method for instruction

in dental bleaching. The use of an adaptive approach is therefore recommended for use in educational curricula.

Ethical approval
The study was approved by the Ethics Committee of the Tehran University of Medical Sciences (IR.TUMS.REC.1394.1362) and registered with the Iranian Registry of Clinical Trials. The electronic content of the course on bleaching single discolored teeth was registered on the CME website of the Ministry of Health and Medical Education available at http://www.ircme.ir (code: 551129502).

Competing interests
There is no competing interest to declare.

Authors' contributions
MZ was involved in study concept, designing of the study, and preparing the manuscript. AM was involved in designing of the study, analyzing data, and preparing the manuscript. SSH was involved in study concept, designing of the study, doing the procedure, and preparing the manuscript.

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