E-learning and Blended Learning in Orthodontic Education

Avinash Kumar

Department of Orthodontics, Al-Badar Dental College and Hospital, Gulbarga, Karnataka, India

Abstract

The purpose of this article is to evaluate how effective and efficient e-learning and blended learning is when compared with traditional face-to-face learning in orthodontic education. This article also provides a comparison between face-to-face learning, e-learning, and blended learning. An open PubMed literature search was done from 1980 to 2015, and a total of 23 relevant key articles were reviewed. Information emerging from studies in orthodontic education has indicated that e-learning classes are at least as good as and/or better than face-to-face classroom learning. Till date, only one study stated that the face-to-face conventional learning is better than e-learning. Two studies stated that blended approach using both traditional face-to-face learning and e-learning is the best method. In one study, the advantages of e-learning observed in the theoretical fields of orthodontics were not achieved in learning practical procedures for manual skills. Few studies found improvements in the efficiency of learning with e-learning program. Studies performed through questionnaires showed that student's attitude and acceptance toward the use of e-learning was positive and favorable; however, blended learning was always rated high. Future research should be based on experiences of both faculty and student on a large scale for implementation of e-learning and blended learning in academic institutions. There is also need to provide professional development for faculty who will be teaching both in the physical and virtual environments.

Keywords: *Blended learning, computer-aided learning, e-learning, face-to-face learning, online learning, orthodontic education*

Introduction

Electronic education has the potential to shift the paradigm from passive teacher-centered learning to active student-centered learning. E-learning is defined as learning in ways that use Information and Communication Technologies (ICTs). E-learning can be synchronous (everyone at the same time) or asynchronous (not at the same time). Synchronous e-learning is where students from diverse locations log into the training at a set time, and an instructor facilitates a discussion while showing slides or writing on a "whiteboard" that appears on the computer screens of the learners. During these sessions, learners can ask questions through messages or sometimes verbally to the faculty instructor. Asynchronous e-learning refers to e-learning that is "prerecorded" or available to students at any time of the day, potentially from any location.[1]

Using the advantages of electronic education, universities are beginning to support traditional face-to-face teaching with online educational tools for dental education.[2] A combination of traditional face-to-face learning and e-learning is called as blended learning. The main advantage of blended learning is that it integrates the strengths of synchronous traditional face-to-face and asynchronous/synchronous web-based learning activities.[3,4]

Rosenberg *et al.*[5] systematically reviewed the effectiveness of computer-aided, self-instructional programs in dental education, and recommended that computer-aided learning (CAL) program is as effective as other methods of learning and has several potential advantages depending on how the program is designed and the students' ease of access to the CAL modules. Gupta *et al.*[2] found that students consider the e-course as a positive method of supplementing traditional methods of learning in the dental undergraduate program. However, in contrast, teaching staff expressed negative views on the use of e-learning. Pahinis *et al.*[6] investigated dental students' perceptions about a blended learning health informatics course that combined online and traditional classroom

Address for correspondence:
Dr. Avinash Kumar,
Department of Orthodontics,
Al-Badar Dental College
and Hospital, Gulbarga,
Karnataka, India.
E-mail: dr.avinashsajjan@
gmail.com

instruction. The online component of the course was accepted as a valuable resource by the majority of learners. Both face-to-face and online-structured sessions were similarly understandable and valued.

In a systematic review of the literature on the effectiveness of e-learning compared face-to-face learning in orthodontic education by Rosenberg et al.,[7] it was concluded that CAL programs in orthodontics can elicit positive responses and attitudes from students toward learning, and there is insufficient evidence to support the complete replacement of conventional teaching with CAL programs in orthodontic training. CAL should be used as an adjunct to conventional teaching or as a mode of self-instruction. Al-Jewair et al.,[8] in their systematic review and meta-analysis concluded that CAL when applied for teaching orthodontic topics related to diagnosis and treatment planning, are at least as effective as conventional modes of orthodontic learning and add an additional small (4%–10%) but significant gain in student knowledge acquisition.

There have been several subsequent studies on face-to-face learning, e-learning, and blended learning in orthodontic education, suggesting that this is a growing area of educational research. In this review, we intend to further investigate the effectiveness and efficiency of e-learning and blended learning compared to face-to-face learning in teaching and learning of orthodontics.

The objectives of this article are (1) to provide a comparison between face-to-face learning, e-learning, and blended learning, (2) to evaluate how effective and efficient e-learning and blended learning is when compared with traditional face-to-face learning in orthodontic education, and (3) to provide ideas for future research that could be beneficial for further blending e-learning in orthodontic education.

Discussion

E-learning

E-learning is the use of ICTs to enhance learning, knowledge, and performance. E-learning refers to the educational system, in which faculty and students are separated by physical distance but with the help of technology, equipment, and tools they are linked together. E-learning requires consideration of the computer literacy of academic staff and students as well as access to computers and high-speed internet infrastructure. Students and faculty must have skills sufficient for them to register, communicate, download, view, and be tested. E-learning technologies offer the learners control over content, learning sequence, pace of learning, time, and often media, allowing them to tailor their experiences to meet their personal learning objectives.[9-11]

E-learning can be supported through different forms such as web-based learning, computer-based learning, or virtual classrooms and content delivery through e-networks, audio or video tape, satellite TV, video conferencing, i-pods, E-mails, wikis, and wireless mobile technology. Learning is the process that takes place from the student's perspective as a result of instructional strategies. Emphasis will be placed on increasing student involvement and making them responsible for their own learning. E-learning offers various benefits such as increased accessibility to information, better content delivery, personalized instruction, content standardization, accountability, self-pacing, interactions in peer groups, confidence building, and increased convenience.[12]

In traditional lecture learning, 33 min after a lecture is completed, students only retain 58% of the material presented. By the 2nd day, only 33% is retained, and 3 weeks after the course is completed, only 15% is remembered.[13] While in e-learning lecture, course material can be accessed several times, from any place, and at any time if something is forgotten which allows students to remember most of the information delivered that they are required to learn in particular course.

The most notable disadvantage of e-learning is its lack of social interaction and loss of human touch. Many students need social interaction to perform academically well and thus find distance learning difficult. There are types of training that simply cannot be taught through e-learning, these are known as soft skills. These include interpersonal skills, verbal, communication, leadership, and initiative. E-learning does not offer the student with the same opportunities of explanation and clarification that occur in face-to-face interaction and feedback in an e-learning environment may be delayed or text-mediated or simply too context-dependent to be able to be recreated through a telephone call or E-mail 2 days later.

Why e-learning in orthodontic education? For visualizing concepts in the form of patient simulations and multimedia instructions, thus supporting the preclinical and clinical teaching and learning; audio/video seminars; information sharing and collaborative working environments through online projects; tracking the learner activities and mastery of the material through formative assessment (e.g., quiz scores); providing immediate feedbacks, thus augmenting the self-paced and self-directed learning; Motivating the students toward learning.[12,14]

Blended learning

Online learning and traditional face-to-face learning have their own respective strengths and weaknesses. Neither is better but rather they are complementary. Blended learning was introduced to take the benefits of both learning methods. Blended learning in the broadest sense can be defined or conceptualized as a wide variety of technology/media integrated with conventional face-to-face classroom activities. Blended learning involves the

appropriate blend of different components which includes courses, contents, feedback, etc. Blended learning can solve the problems associated with most e-learning models. In blended learning, faculty must know when to shift gears, add new tasks, and when to let the learners to explore their own interests.[15]

The integration of blended learning (physical and virtual) into dental education can catalyze the shift toward applying constructivist learning theory, where faculty will no longer serve as the distributors of knowledge content but will become more involved as facilitators of learning and assessors of competency. The students should complete e-modules of self-learning on a given topic before coming to the classroom. The classroom-based learning is then used for the interactive elements of the learning, such as role-plays and discussion. By conducting part of the learning asynchronously, part of it by synchronously through online learning, and only the most interactive part in a classroom learning, the information can be delivered over a longer period and thus improves the student retention. Blended learning is also a viable way to augment faculty resources and to help overcome faculty shortages.[15]

Learning pyramid indicates different levels of retention for different activities. According to learning pyramid, learners retain approximately 90% of what they learn when they teach someone else/use immediately; 75% when they practice what they learned; 50% when they are engaged in a group discussion; 30% when they see a demonstration; 20% from audio-visual; 10% from reading; and 5% from lecture.[16,17] The goal of blended learning is to provide the most efficient and effective instruction experience by combining delivery modalities. It may involve usage of computer, cellular or smart phones, satellite television channels, video conferencing, and other emerging electronic media.

A comparison table is provided which summarizes the various teaching and learning methods in an education system [Table 1].

E-Learning and Blended Learning in Orthodontic Education

This review is based on an open PubMed literature search from 1980 to 2015 with key words face-to-face learning, e-learning, online learning, computer-aided learning, web-based learning, blended learning, and orthodontic education. Twenty-three studies were identified which were relevant to face-to-face to learning, e-learning, and blended learning in orthodontic education.

The learning outcomes of traditional face-to-face learning e-learning and blended learning in orthodontic education were compared through concrete objectives such as, effectiveness: knowledge, skills, attitudes, and acceptance of learning methods (cognitive, psychomotor, affective domain of bloom's educational objectives); efficiency (time, cost, and flexibility); and self-assessment (meta-cognitive domain). The included studies are summarized in Table 2.

Effectiveness

There are four important questions about effectiveness of e-learning that have been addressed in this review.

Table 1: Comparison between teaching and learning methods in an education system		
Face-to-face learning	**E-learning**	**Blended learning**
Traditional lectures and seminars for teaching and learning	It utilizes ICT for teaching and learning	In the broadest sense, blended learning can be defined or conceptualized as a wide variety of technology/media integrated with conventional (face-to-face) classroom activities
The subject matter according to the study program and curriculum	The subject matter is richer and includes material in different formats	It utilizes benefits of both face to face and online learning
Full control of the faculty (teacher-centered learning)	Multimedia support with augmentation of text, audio, video, animation, and virtual simulation	Learning a part of subject, asynchronously, part of it synchronously through online learning, and only the most interactive part in face-to-face classroom learning
Discussions are held at a fixed time and fixed location	Full control of learner (student-centered learning)	It bridges the gap between theoretical knowledge and the practical skills
Reading textbooks and printed materials for self-study and self-evaluation	Discussions (synchronous/asynchronous) are held at any time and from any location	Subject information is delivered over a long periodHigh knowledge retention
Does not meet the needs of all student learners with different learning style preferences	Use of digital multimedia technologies for self-study and self-evaluation example; video, audio, three-dimensional animation, weblinks, etc.	High motivation for learning
Less attention in the class	Meets the needs of most student learners with different learning style preferences	Highly effective for distance learning
Less retention of knowledge	More attention in the class	
Less motivation to learn	More knowledge retention	
Not effective for distance learning	Increased motivation to learn	
	Effective for distance learning	

ICT – Information and communication technology

Table 2: Summary of the key studies comparing conventional learning, e-learning, and blended learning in orthodontic education

Study	Subject (theory/practical)	Aim of the study	Participants	Effectiveness and efficiency of the study	Acceptance and attitudes of students and faculty
Luffingham 1984[18]	Orthodontic principles	To compare effectiveness of CAL versus traditional tutorials	60 undergraduate students	CAL presentation of orthodontics clinical data is an effective and popular addition to traditional teaching	Not applicable
Irvine and Moore 1986[19]	Mixed dentition analysis	To compare effectiveness of CAL program with traditional lectures	52 3rd year undergraduate students	The CAL group performed significantly better on the posttest than did the lecture group

There was no significant correlation between posttest scores and the time used to view the program for students in the CAL group | Student's attitude toward the use of CAL program was favorable |
| Turner and Weerakone 1993[20] | Principles of cephalometric analysis | To evaluate the efficacy of knowledge gain of the hypertext system versus conventional system | 40 3rd year undergraduate students | No significant difference between the groups | Students liked and enjoyed the hypertext system |
| Clark et al. 1997[21] | Principles of cephalometrics and tracing technique | To compare the effectiveness of a computer-based hypertext system versus conventional lecture | 52 1st year clinical undergraduate students | No significant difference between the groups | 3/4th of students said CAL was enjoyable and 1/4th of students said it is time-consuming and faced difficulty in following the course |
| Hobson et al. 1998[22] | Diagnosis and basic principles of treatment planning | To compare effectiveness of CAL versus traditional seminars | 49 4th year undergraduate students | Significant knowledge gain in conventional seminar group compared to CAL group

There was no significant difference between the 2 groups for self-directed learning | Both forms of teaching were rated highly

Aims of teaching had been met better by the tutorial than by the CAL teaching sessions |
| Marsh et al. 2001[23] | Continuing education module on super-elastic archwires for the initial stage of orthodontic treatment | To evaluate the interest and reaction of practicing orthodontists to educational materials delivered with and without the dynamic graphics | 116 practicing orthodontists | The computer program was effective in changing clinical behavior | Additional graphics to improve the appearance of the teaching program are unnecessary and perhaps counterproductive |
| Lowe et al. 2001[24] | IOTN | To identify if a lecture or access to a CAL program is more effective in teaching undergraduate dental students IOTN | 85 3rd year undergraduate students | There was no difference in mean score for the two groups

There was statistically significant difference for DHC grade. The CAL group of students performed best | Not applicable |

Contd...

Study	Subject (theory/ practical)	Aim of the study	Participants	Effectiveness and efficiency of the study	Acceptance and attitudes of students and faculty
Komolpis and Johnson 2002[25]	Clinical orthodontic diagnosis	To describe the design and set-up of the website and define how the site might be used as a resource for small-group learning in a preclinical orthodontic course	99 2nd year predoctoral students	There were no statistically significant differences between mean test scores or mean test times Digital orthodontic records appear to be comparable to conventional records	Attitudes of students toward the website, assessed from posttest questionnaires, were positive
Aly et al. 2003[26]	Orthodontic diagnosis and different treatment possibilities	To develop and evaluate an interactive multimedia courseware for interactive means of self-study and self-evaluation	25 3rd year, 25 4th year, 25 5th year Undergraduate and 25 postgraduate students in orthodontics	Not applicable	Majority of undergraduate and postgraduate students were very enthusiastic about the approach (74/100) Students experienced it to be very helpful in understanding the orthodontic curriculum (98/100) A useful interactive means of self-study and self-evaluation
Aly et al. 2004[27]	Undergraduate orthodontic curriculum	To compare the effectiveness of interactive multimedia program versus standard lecture regarding knowledge, understanding, and transfer of content, as well as problem-solving in orthodontics	26 final year undergraduate students	Instructional multimedia program was at least as effective as the standard lecture	Better understanding of the course content with instructional multimedia program
Nurko and Proffit 2005[28]	Advanced clinical orthodontics for a predoctoral course	To evaluate the acceptability of students and the perceived effectiveness of Web-based self-instruction plus small-group seminars	Not mentioned	Web-based self-instruction plus small-group seminars coordinated by a course leader is at least as effective as traditional lectures	Students ranked the modules and seminars as excellent and felt that both were educationally quite effective
Bednar et al. 2007[29]	3 types of seminars	To compare the acceptability and the effectiveness in terms of learning gains of several modes of instruction, using a distant instructor and high-speed Internet links	Orthodontic residents and faculty from 3 schools	The improvement from pretest to posttest scores after observing a sequence of distance seminars was similar to that with direct instruction	Orthodontic residents rated the educational experiences positively Live participation in seminars via video conferencing was preferred
Miller et al. 2007[30]	Distance learning based on the observation of recorded seminars and follow-up interaction for residents and practicing orthodontists	To evaluate the effectiveness and acceptability video conferencing, audio-only interaction by telephone, and Internet chat with Net Meeting software during distance learning	Residents from 3 schools	Not applicable	An acceptable method of instruction Eases the strains of current faculty shortages Video conferencing received the highest ratings

Contd...

Table 2: Contd...
Study	**Subject (theory/ practical)**	**Aim of the study**	**Participants**	**Effectiveness and efficiency of the study**	**Acceptance and attitudes of students and faculty**
Retrouvey *and* Finkelstein 2008[31]	Orthodontic diagnosis	To bridge the gap between theoretical knowledge and the practical skills using interactive multimedia programs	Not mentioned	Not applicable	Student's liked the concept of blended learning and their rate of learning and retention of knowledge seem superior to those using conventional lecture
Mulgrew *et al.* 2009[32]	Modular teaching program for academic training of orthodontic postgraduates	To evaluate whether it's had reduced travel commitments for trainees, reduced demands on academic staff and whether it had any effect on teaching and learning	Nine trainees and 14 trainers	Travel commitments for trainees have reduced as a result of introducing the web-based resource, but not as expected. Demands on academic staff have not reduced but have changed. The resource has had positive effects on postgraduate orthodontic teaching and learning	Improvements in the flexibility and efficiency of learning Trainees continue to value the opportunity to interact face to face with their teachers and peers
Linjawi *et al.* 2009[33]	Orthodontic e-course	To develop an online undergraduate orthodontic e-course and assess its success as a learning resource from the students' perspective	64 3rd year undergraduate students. (26 males and 38 females)	There was no significant difference between genders. The significance of the program as a learning resource was reported to be the best aspect of the program	Student responded "very positive" to "positive" for course design, course delivery and course outcome Orthodontic e-course was still seen by most subjects (86%) as an adjunct and not a replacement of the traditional teaching methods
Rosenberg *et al.* 2010[34]	Orthodontic diagnosis of developing malocclusion	To elicit and assess student's perceptions of the ODET; to assess whether there is a correlation between objective outcome measures and subjective outcome measures; and to assess whether there are any differences in outcomes between the subgroups of male versus female	92 4th-year undergraduate dental students (38 men, 54 women)	In the male and female subgroups, a statistically significant difference in mean lecture test scores favoring women over men was observed, and this difference was not observed for mean ODET test scores. Increased self-reported time spent reviewing the tutorial was weakly correlated with improved ODET test scores	Male students preferred self-instruction as a mode of learning more than female students Students were positive for acceptability and usability of the electronic tutorial and educational quality of the tutorial. However, the students were not prepared to replace lectures with CAL tutorials

Contd...

Table 2: Contd...

Study	Subject (theory/ practical)	Aim of the study	Participants	Effectiveness and efficiency of the study	Acceptance and attitudes of students and faculty
Bains *et al.* 2011[35]	Cephalometrics	To compare e-learning, face-to-face learning and blended learning with respect to their effectiveness and student attitudes towards them	157 4th year undergraduate students and 90 students completed the study	No statistically significant difference between face-to-face learning and blended learning E-learning alone was less effective	Blended learning was the most and face to face learning was the least accepted Only e-learning was significantly less preferred
Klein *et al.* 2012[36]	Growth and development, advanced diagnosis and treatment planning, advanced biomechanics, and sequellae of treatment	To measure programmatic interest in using blended distance learning, to determine resident and faculty interest, to determine the seminars' perceived usefulness, and to elicit feedback regarding future use	256 residents and 42 faculties	Not applicable	The blended approach to distance learning was judged to be effective and enjoyable; faculty members were somewhat more enthusiastic about the experience than were residents
Ireland *et al.* 2013[37]	Wiki topic teaching in postgraduate orthodontics	What do the learners think?	9 postgraduate students	Not applicable	Students felt writing the Wikis were useful for teamwork, provided the approach was more learner-centred
Ludwig *et al.* 2015[38]	Cephalometric tracing skills	Assessment of traditional learning and two e-learning methods	30 undergraduate students	Both e-learning groups improved more than the traditional group	Not applicable
Naser-ud-Din 2015[39]	SBLi® software for orthodontics postgraduate training	To investigate learning styles and the acceptance of e-modules as part of postgraduate training	Not mentioned	Not applicable	High acceptance rate, greater confidence in the application of clinical skills E-modules demonstrated high compatibility with the learning styles of the participants
Schorn-Borgmann *et al.* 2015[40]	Manufacturing of three orthodontic appliances (Schwarz Plate, U-Bow Activator, and Fränkel Regulator)	To evaluate the effect of online demonstrations concerning the quality of orthodontic appliances manufactured by undergraduate dental students	44 participants	No significant differences were found between 3 groups (conventional lectures group, conventional lectures plus written online material group, and access to resources of groups one and two plus access to online video material group)	Not applicable

IOTN – Index of Orthodontic Treatment Need; SBLi® – Scenario Based Learning Interactive; CAL – Computer-aided learning; ODET – Orthodontic diagnosis electronic tutorial; DHC – Dental health component

(1) Whether the e-learning classes are better than or at least as good as face-to-face classroom learning? (2) Is blended learning more effective than only e-learning or face-to-face learning? (3) Are classes conducted through e-learning equally effective for theoretical learning and practical manual skills? (4) Is e-learning (distance learning) effective for continuing orthodontic education for residents and practicing orthodontists?

First, whether the e-learning classes are better than or at least as good as face-to-face classroom learning?

Information emerging from published studies in orthodontic education has indicated that E-learning classes are better than face-to-face in some studies and in few studies at least as good as face-to-face classroom learning. Turner and Weerakone[20] and Clark et al.[21] found that no significant difference in knowledge gain between the hypertext system versus conventional system on the subject of principles of cephalometrics, tracing technique, and analysis. Luffingham[18] concluded in his study that the CAL presentation of orthodontic clinical data is an effective and popular addition to traditional face-to-face learning. Lowe et al.[24] found that undergraduate dental students can learn to use index of orthodontic treatment need as well or better when using a CAL program compared with a lecture. Irvine and Moore[19] found that the CAL group performed significantly better on the posttest than did the lecture group in learning mixed dentition analysis. Aly et al.[27] found that the instructional interactive multimedia program to be at least as effective as the standard lecture of the orthodontic curriculum for undergraduate training in orthodontics and stated that the CAL is an effective way of increasing knowledge, understanding, and application in teaching orthodontics. Komolpis and Johnson[25] found that there were no statistically significant differences between mean test scores and concluded that web-based digital orthodontic records were as effective in teaching clinical orthodontic diagnosis as were conventional records. Nurko and Proffit[28] found that web-based self-instruction plus small-group seminars coordinated by a course leader is at least as effective as traditional lectures. This approach can become a way to share faculty resources among schools so that an instructional expert in a particular area could manage the teaching of that subject at several institutions. For maximum effectiveness, the distant faculty member should be involved in both the development of the instructional modules and the small-group discussions. Mulgrew et al.[32] found that travel commitments for trainees have reduced as a result of introducing the web-based resource, but not as expected. Demands on academic staff have not reduced but have changed. The resource has had positive effects on postgraduate orthodontic teaching and learning. Linjawi et al.[33] assessed an online undergraduate orthodontic e-course design and concluded that orthodontic e-course is effective as a learning resource for the students. Ludwig et al.[38] investigated the tracing skills of traditional learning group and two e-learning groups after all undergraduate students underwent traditional training of cephalometry consisting of lectures and tutorials. They found that both e-learning groups improved more than the traditional group and blended learning produced better learning outcomes compared to using a traditional teaching method alone.

Till date, only one study states that face-to-face conventional tutorial learning is better than CAL. Hobson et al.[22] used a text-based CAL package designed to teach orthodontic assessment and basic principles of treatment planning and compared with conventional teaching. Both the student groups made significant gains in knowledge. However, students who were taught by the conventional tutorial made a significantly greater gain than those taught by CAL.

The second question with regard to effectiveness is whether blended learning is more effective than only e-learning or face-to-face learning? Few studies stated that blended approach using both traditional face-to-face learning and e-learning is the best method of learning and teaching. Retrouvey and Finkelstein[31] evaluated the use of blended learning in orthodontic diagnosis, which incorporated multimedia and self-directed learning module into undergraduate curriculum. The goal was to bridge the gap between theoretical knowledge and the practical skills needed to be a successful dentist. Multimedia program on orthodontic diagnosis was well received by students as it allows them to learn at their own pace and apply the knowledge by carrying out simple but effective exercises. Student's performance was better using the technology than they did after traditional lectures. Bains et al.[35] found that there is no statistically significant difference between face-to-face learning and blended learning. E-learning alone was less effective when delivering Cephalometric education to undergraduates.

The third question with regard to effectiveness is whether e-learning is equally effective for theoretical and practical learning. The advantages of e-learning observed in the theoretical fields of orthodontics were not achieved in the educational procedures for manual skills. Schorn-Borgmann et al.[40] evaluated the effect of online demonstrations concerning the quality of three orthodontic appliances (Schwarz Plate, U-Bow Activator, and Fränkel Regulator) manufactured by undergraduate dental students. Fifty-four participants were randomly assigned to one of the three groups: conventional lectures, conventional lectures plus written online material, and third group with access to resources of groups one and two plus access to online video material. No significant differences were found between the groups. They concluded that students could use additional time and course-independent e-learning resources did not increase the outcome quality of the orthodontic appliances.

The fourth question with regard to effectiveness is whether e-learning (distance learning) is effective for continuing orthodontic education for residents and practicing orthodontists? Miller et al.[30] found that distance learning based on the observation of recorded seminars, and follow-up interaction is an acceptable method of instruction that can allow residents and practicing orthodontists to access various materials and experts, and perhaps help to ease the strains of current faculty shortages. Video conferencing received the highest ratings, telephonic interaction was a close second in mean scores, and Internet chat was a distant third. All residents stated that they would

like to be taught through distance education again. In a study by Klein et al.,[36] blended approach was judged to be effective as compared to distance e-learning that allows residents to access various experts, supplement traditional instructor-led training, and eases the strain of current faculty shortages. Marsh et al.[23] concluded that for orthodontists who are comfortable with the concept of computer instruction, a high-level computer instructional program can change behavior in a clinical setting and additional graphics to improve the appearance of the teaching program are unnecessary and perhaps counterproductive.

Efficiency, acceptability, and appeal

The initial investment required to develop a highly interactive e-learning course can be high; later there were more savings due to a reduction in cost of classroom facilities, faculty, and cost of printed materials. Rosenberg et al.[34] found that the improved performance on the orthodontic diagnosis electronic tutorial (ODET) test was noted for students who reported longer times spent reviewing the tutorial. Mulgrew et al.,[32] found improvements in the flexibility and efficiency of learning with modular teaching program and students continued to value the opportunity to interact face-to-face with their teachers and peers.

Numerous studies performed through questionnaires showed that student's attitude and acceptance toward the use of e-learning was favorable, and blended learning is always rated high in orthodontic undergraduate and postgraduate training. Irvine and Moore[19] found that student's attitude toward the use of CAL program was favorable in learning-mixed dentition analysis. Turner and Weerakone[20] concluded that students liked and enjoyed the hypertext system in learning principles of cephalometrics and analysis, however; Clark et al.,[21] in their study found that the 3/4 of students said CAL was enjoyable and 1/4 of students said its time consuming and faced difficulty in following the course. Komolpis and Johnson[25] found that attitudes of students toward the design and set-up of the website, in learning a preclinical orthodontic course were positive. Aly et al.[26] concluded from his study that majority of undergraduate and postgraduate students were very enthusiastic about interactive multimedia courseware (74/100) and students experienced that courseware was very helpful in understanding the orthodontic curriculum (98/100). Linjawi et al.[33] found that student responded "very positive" to "positive" for orthodontic e-course design, course delivery, and course outcome. The orthodontic e-course was seen by most students (86%) as an adjunct and not a replacement of the traditional teaching methods. 34.4% of subjects felt that it should be as an optional supplement and 51.6% felt that it should be integrated with the undergraduate orthodontic curriculum. Rosenberg et al.[34] found that students are not prepared to replace lectures with CAL tutorials and

appealed that the ODET should continue to be used along with traditional learning. Naser-ud-Din[39] found high acceptance rate, greater confidence in the application of clinical skills with Scenario Based Learning Interactive (SBLi®) software (Identic Pty Ltd.) for orthodontics postgraduate training. E-modules demonstrated high compatibility with the learning styles of the participants. Bains et al.[35] found that undergraduate students were more positive toward blended learning than face-to-face learning or e-learning alone in learning cephalometrics. Bednar et al.[29] found that the acceptability of the distance seminars appeared to be influenced by the instructor's personality and teaching style in facilitating interaction, the seminar subject, the residents' comfort level in dealing with this technology, and the sequence for interaction versus observation. Klein et al.,[36] concluded from their study that the blended approach compared to distance learning was judged to be acceptable and enjoyable; faculty members were somewhat more enthusiastic about the experience than were residents. Most residents and faculty agreed that they would like to use this approach to distance learning again. Retrouvey and Finkelstein[31] concluded from their study that student's such as the concept of blended learning and their rate of learning and retention of knowledge seem superior to those using conventional lecture. Ireland et al.[37] found that the Wiki topic teaching is a useful tool in the teaching of postgraduate orthodontics providing variation and a more learner-centered approach. Students felt writing the Wikis was useful for teamwork, created a body of work in a live format that would be useful for revision and was a welcome variation on traditional teaching methods.

Self-assessment

Aly et al.[26] found interactive computer software package to be a user-friendly way for both undergraduates and postgraduates to understand the orthodontic curriculum. They concluded that e-learning program provided the dental undergraduate and postgraduate students with an interactive means of self-study and self-evaluation.

Gender difference

Rosenberg et al.[34] found that there was a difference in lecture test scores between male and female students, and no significant difference in mean ODET test scores; this might be explained by the sex differences in terms of learning style preferences, with men preferring self-instruction more than women. Linjawi et al.[33] found that there was no significant difference between genders in learning orthodontic e-course for undergraduate students.

Future research

There is limited evidence on the effectiveness and efficiency of both e-learning and blended learning in orthodontic education. The new teaching and learning technologies should be tested thoroughly before implementing into the education system. Experiences of both faculty and student

should be investigated on a large scale for implementation of e-learning or blended learning in academic institutions. Universities should invest into research in the area of e-learning and blended learning in orthodontic education. There is also a need to provide professional development for faculty who will be teaching both physically and virtually. E-learning would increase the use of mobile and wireless technology. Mobile blended learning technologies will also be able to make learning more easily accessible for a wider range of individuals, thereby creating greater opportunities for lifelong learning. Future research should be including mobile blended learning technologies in teaching of orthodontics.

Conclusion

Evidence emerging from published key studies in orthodontic education has indicated that e-learning classes are at least as good as and/or better than face-to-face classroom learning and blended approach which combines both traditional face-to-face learning and e-learning is the best method of teaching and learning.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Rosenberg MJ. E-learning: Strategies for delivering knowledge in the digital age. New York: McGraw-Hill; 2001. p. 19-35.
2. Gupta B, White DA, Walmsley AD. The use of internet based teaching in a dental undergraduate curriculum. Br Dent J 2004;196:487-92.
3. Pahinis K, Stokes CW, Walsh TF, Tsitrou E, Cannavina G. A blended learning course taught to different groups of learners in a dental school: Follow-up evaluation. J Dent Educ 2008;72:1048-57.
4. Garrison DR, Kanuka H. Blended learning: Uncovering its transformative potential in higher education. Internet High Educ 2004;7:95-105.
5. Rosenberg H, Grad HA, Matear DW. The effectiveness of computer-aided, self-instructional programs in dental education: A systematic review of the literature. J Dent Educ 2003;67:524-32.
6. Pahinis K, Stokes CW, Walsh TF, Cannavina G. Evaluating a blended-learning course taught to different groups of learners in a dental school. J Dent Educ 2007;71:269-78.
7. Rosenberg H, Sander M, Posluns J. The effectiveness of computer-aided learning in teaching orthodontics: A review of the literature. Am J Orthod Dentofacial Orthop 2005;127:599-605.
8. Al-Jewair TS, Azarpazhooh A, Suri S, Shah PS. Computer-assisted learning in orthodontic education: A systematic review and meta-analysis. J Dent Educ 2009;73:730-9.
9. Schittek M, Mattheos N, Lyon HC, Attström R. Computer assisted learning. A review. Eur J Dent Educ 2001;5:93-100.
10. Eynon R, Perryer G, Walmsley AD. Dental undergraduate expectations and opinions of Web-based courseware to supplement traditional teaching methods. Eur J Dent Educ 2003;7:103-10.
11. Hendricson WD, Panagakos F, Eisenberg E, McDonald J, Guest G, Jones P, et al. Electronic curriculum implementation at North American dental schools. J Dent Educ 2004;68:1041-57.
12. Mattheos N, Stefanovic N, Apse P, Attstrom R, Buchanan J, Brown P, et al. Potential of information technology in dental education. Eur J Dent Educ 2008;12 Suppl 1:85-92.
13. Jones ME, Simonetti JL, Vielhaber-Hermon M. Building a stronger organization through leadership development at Parke-Davis research. Ind Commer Train 2000;32:44-8.
14. Bearn D, Lowe C. Computer-aided learning in orthodontics: Is there any out there? J Orthod 2001;28:314-6.
15. Graham CR. Blended learning systems: Definition, current trends, and future directions. In: Bonk CJ, Graham CR, editors. Handbook of Blended Learning: Global Perspectives, Local Designs. San Francisco, CA: Pfeiffer Publishing; 2013. p. 3-21.
16. NTL Institute for Applied Behavioral Science. Available from: http://www.homepages.gold.ac.uk/polovina/learnpyramid/about.htm. [Last accessed on 2011 Nov 16].
17. Lalley JP, Mille RH. The learning pyramid: Does it point teachers in the right direction? Education 2007;128:64-79.
18. Luffingham JK. An assessment of computer-assisted learning in orthodontics. Br J Orthod 1984;11:205-8.
19. Irvine NR, Moore RN. Computer-assisted instruction in mixed dentition analysis. J Dent Educ 1986;50:312-5.
20. Turner PJ, Weerakone S. An evaluation of a hypertext system for computer-assisted learning in orthodontics. Br J Orthod 1993;20:145-8.
21. Clark RD, Weekrakone S, Rock WP. A hypertext tutorial for teaching cephalometrics. Br J Orthod 1997;24:325-8.
22. Hobson RS, Carter NE, Hall FM, Atkins MJ. A study into the effectiveness of a text-based computer-assisted learning program in comparison with seminar teaching of orthodontics. Eur J Dent Educ 1998;2:154-9.
23. Marsh CM, Hannum WH, Trotman CA, Proffit WR. Evaluation of the acceptability and effectiveness of a CD-ROM continuing education program for orthodontists. Angle Orthod 2001;71:71-7.
24. Lowe CI, Wright JL, Bearn DR. Computer-aided Learning (CAL): An effective way to teach the Index of Orthodontic Treatment Need (IOTN)? J Orthod 2001;28:307-11.
25. Komolpis R, Johnson RA. Web-based orthodontic instruction and assessment. J Dent Educ 2002;66:650-8.
26. Aly M, Willems G, Carels C, Elen J. Instructional multimedia programs for self-directed learning in undergraduate and postgraduate training in orthodontics. Eur J Dent Educ 2003;7:20-6.
27. Aly M, Elen J, Willems G. Instructional multimedia program versus standard lecture: A comparison of two methods for teaching the undergraduate orthodontic curriculum. Eur J Dent Educ 2004;8:43-6.
28. Nurko C, Proffit WR. Acceptability and perceived effectiveness of web-based self-instruction in clinical orthodontics. Angle Orthod 2005;75:521-5.
29. Bednar ED, Hannum WM, Firestone A, Silveira AM, Cox TD, Proffit WR. Application of distance learning to interactive seminar instruction in orthodontic residency programs. Am J Orthod Dentofacial Orthop 2007;132:586-94.
30. Miller KT, Hannum WM, Morley T, Proffit WR. Use of recorded interactive seminars in orthodontic distance education. Am J Orthod Dentofacial Orthop 2007;132:408-14.
31. Retrouvey JM, Finkelstein AB. Blended learning in orthodontic diagnosis: An interactive approach. J Can Dent Assoc 2008;74:645-9.
32. Mulgrew B, Drage K, Gardiner P, Ireland T, Sandy JR. An

evaluation of the effects of a web-based modular teaching programme, housed within a virtual learning environment on orthodontic training for specialist registrars. J Orthod 2009;36:167-76.

33. Linjawi AL, Hamdan AM, Perryer DG, Walmsley AD, Hill KB. Students' attitudes towards an on-line orthodontic learning resource. Eur J Dent Educ 2009;13:87-92.

34. Rosenberg H, Posluns J, Tenenbaum HC, Tompson B, Locker D. Evaluation of computer-aided learning in orthodontics. Am J Orthod Dentofacial Orthop 2010;138:410-9.

35. Bains M, Reynolds PA, McDonald F, Sherriff M. Effectiveness and acceptability of face-to-face, blended and e-learning: A randomised trial of orthodontic undergraduates. Eur J Dent Educ 2011;15:110-7.

36. Klein KP, Hannum WM, Koroluk LD, Proffit WR. Interactive

distance learning for orthodontic residents: Utilization and acceptability. Am J Orthod Dentofacial Orthop 2012;141:378-85.

37. Ireland AJ, Atack NE, Sandy JR. Experiences of Wiki topic teaching in postgraduate orthodontics: What do the learners think? Eur J Dent Educ 2013;17:e109-13.

38. Ludwig B, Bister D, Schott TC, Lisson JA, Hourfar J. Assessment of two e-learning methods teaching undergraduate students cephalometry in orthodontics. Eur J Dent Educ 2016;20:20-5.

39. Naser-ud-Din S. Introducing Scenario Based Learning interactive to postgraduates in UQ Orthodontic Program. Eur J Dent Educ 2015;19:169-76.

40. Schorn-Borgmann S, Lippold C, Wiechmann D, Stamm T. The effect of e-learning on the quality of orthodontic appliances. Adv Med Educ Pract 2015;6:545-52.