Review Article

Perception of undergraduate dental students from digital learning vs. conventional learning: A systematic review and meta-analysis

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Abstract

Background & Objective: This study aimed to compare the perception of undergraduate dental students with digital, blended, and conventional learning experiences.

Materials & Methods: A search of the literature was performed in PubMed, Cochrane, Scopus, Web of Science, and Embase databases with keywords of study, yielding 3541 articles. Educational intervention studies that compared undergraduate dental students' perceptions toward digital and traditional learning were included. The quality of articles was analyzed by the risk of bias 2 (ROB2). Using Comprehensive Meta-Analysis software and a random-effect model, 4 main outcomes of self-reported acquired knowledge, self-reported acquired competence, satisfaction level, and usefulness of learning were compared among the E-learning, blended, and conventional groups. The standardized mean difference (SMD) was calculated. The GRADE approach was used to analyze the certainty of evidence.

Results: After removing the duplicates and assessing the abstract and full text of the articles, 23 articles were systematically reviewed, and 15 articles underwent meta-analysis. In quantitative analysis, 13 studies had a high risk of bias and 2 had some concern risk of bias. No significant difference was found among the E-learning, blended and conventional learning in self-reported acquired knowledge (SMD=0.19, 95% CI: -0.20-0.58, P=0.34), self-reported competence (SMD=-0.07, 95% CI: -0.57-0.43, P=0.77), satisfaction level (SMD=0.05, 95% CI: -0.42-0.31, P=0.77) or usefulness of learning (SMD=0.28, 95% CI: -0.72-0.15, P=0.2).

Conclusion: No significant difference was noted among the E-learning, blended and conventional groups in self-reported acquired knowledge and competence, satisfaction level, and usefulness of learning to accord to the opinion of undergraduate dental students. However, considering the low level of evidence, the results should be interpreted with caution.

Keywords: Dental student; Digital Learning; Perception

Introduction

Digital technology has transformed many aspects of life (1). As a result, education has also undergone some significant changes (2). The United Nations Educational, Scientific and Cultural Organization (UNESCO) suggested higher education institutes should develop and use new technologies in response to new expected social (3). Digital technology has been adopted by educational organizations to achieve learning goals (1). By the growing educational needs, the conventional face-to-face method cannot respond to students' learning needs, and new cost-effective educational approaches are required (4). Considering emerging diseases such as COVID-19 and the required social distancing, the need for distance learning is clearer than ever (5). Digital learning may address this need (6). Digital learning was introduced by Jay Cross in 1999 (7). Different definitions are available for

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digital learning. The most comprehensive definition was offered by the American Society of Training and Education (ASTD) which described digital learning as a process through which, the contents are learned to use digital media, which include the Internet, computer, satellite broadcasting, audiotapes, videotapes, interactive TV, and compact discs (8).

Digital learning has several advantages, such as flexibility in time and place, reduction of teaching costs (2, 9), attractiveness (2), and increased knowledge retention (10). However, this mode of education has some limitations as well, such as distance from human relations and communication, dependence on the virtual world, the cost required for the establishment of infrastructures, poor computer knowledge of some learners and instructors, unequal access of learners to computer and Internet (2). In developing countries such as Iran, challenges are found in budget and shortage of full-time faculty members, which need to receive more attention. Digital learning may cover these mentioned limitations (11).

There are different studies about dental students' perceptions of digital learning. Different aspects of dental students' perception have been evaluated such as acquired knowledge (12-15), satisfaction (14-19), preferences (20, 21), attitude (16, 21), comfort (17, 22), acceptance (23) and usefulness (17, 22). Emerging diseases have forced digital learning into educational sectors. Providing data on self-reported learners' perceptions may be important. To the best of the authors' knowledge, no systematic review is available on this topic. Also, existing studies have reported conflicted and scattered information about undergraduate dental students' perception of digital learning. Thus, this systematic review and meta-analysis aimed to compare the perception of undergraduate dental students from digital learning vs conventional learning.

Materials & Methods

Design and duration

This systematic review and meta-analysis were conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) checklist (24). The study was approved by the Research Deputy of the Mashhad University of Medical Sciences (IR.MUMS.DENTISTRY.REC.1400.067).

Data sources and search strategy

Laboratory technicians, or post-graduate dental students, were excluded. Articles with unavailable full the search were conducted in five databases (PubMed, Scopus, Web of Sciences, Embase, and Cochrane) up to April 2022. A search was also conducted in Persian language databases of Magiran, Irandoc, SID, and Civilika, but yielded no results. The search strategy for PubMed was ((digital learning) OR (learning software) OR (E-learning) OR (computer-based learning) OR (learning management system) OR (Educational Technology) OR ("Educational Technology" [Mesh])) AND (dental OR dentistry OR "Dentistry" [Mesh]) AND ((student) OR "Students" [Mesh]) AND ((perception) OR "Perception"[Mesh] OR (learning experience) OR (satisfaction) OR ("Personal Satisfaction" [Mesh])OR (attitude) OR "Attitude" [Mesh] OR (knowledge)). Perception is defined as "the process by which the nature and meaning of sensory stimuli are recognized and interpreted" in MeSH. Since different studies assessed the perception of dental students with different parameters, synonyms such as self-reported learning experience, satisfaction, knowledge, attitude, and competence of students were also included.

Eligibility criteria

Inclusion criteria

The inclusion criteria were based on the PICOS question. (P) undergraduate dental students, (I) different digital tools and platforms, (C) conventional face-to-face learning with or without PowerPoint presentation, (O) self-reported acquired knowledge, self-reported acquired competence, satisfaction level, usefulness, perceived stress, adequacy of learning method, enjoyment, motivation, and acceptance of learning method, (S) randomized clinical trials with parallel or crossover design published in the English language without time limitation. All trials evaluated undergraduate dental students' perception of any digital learning methods compared to conventional learning. Self-reported perceptions of dental students had been assessed by a questionnaire.

Exclusion criteria

Case-control studies, cross-sectional studies, cohort studies, review studies, quasi-experimental studies, and pilot studies were excluded. Any trials comparing only

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the digital learning methods, assessing only the perception of students in the intervention group about the method of instruction, or studies on oral hygienists, laboratory technicians, or post-graduate dental students were excluded. Articles with unavailable full text and receiving no response from the corresponding author after 2 attempts were also excluded.

Study selection

After removing the duplicates, a two-phase study selection strategy was adopted. In the first phase, the titles and abstracts of articles were independently evaluated by two authors (T.M. and F.GH). In the second phase, the full text of the selected articles was then evaluated by the same authors. The third researcher (M.E) made the final decision when there was a disagreement. When the full text was not available, the corresponding authors were contacted by email. A hand search in related references was also done.

Data extraction

Data including the first author's name, publication year, country, study design, sample size, academic level of students, age and gender of students, type of E-learning, outcomes, type of scale used, statistical results, and summary of the findings were extracted by one researcher (F. GH). The accuracy of the retrieved data was double-checked by M.E and T.M.

Outcome measurement

The assessed outcomes included self-reported acquired knowledge, self-reported acquired competence, satisfaction level, usefulness, perceived stress, adequacy of learning method, enjoyment, motivation, and acceptance of learning method were measured by using a questionnaire developed by researchers with a Likert scale. Because of variability in reporting of "perception" and the insufficient number of articles, outcomes from all the trials could not be pooled. Therefore, four main outcomes, including self-reported acquired knowledge, self-reported acquired competence, satisfaction level and usefulness of learning, were considered for quantitative analysis. It should be noted there were enough articles in the mentioned outcomes.

Risk of bias and assessment of the quality of evidence

The quality of the retrieved articles was evaluated by the Revised Cochrane Risk of Bias Tool for Randomized Trials (ROB2) (25). It analyzes the risk of bias in articles based on 5 domains (randomization process, deviation from intended intervention, missing outcome data, outcome measurement and selective reporting of results). The overall risk of bias in each article was categorized as low, some concern, and high. Besides, the quality of the evidence was assessed using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) Framework (25). Based on the five domains (risk of bias, imprecision, inconsistency, indirectness and publication bias) of the GRADE framework, the certainty of the evidence was assigned as very low, low, moderate, and high.

Data analysis

All data were statistically analyzed with Comprehensive Meta-Analysis software version 2 (BioStat, Englewood, New Jersey, USA). Because of the heterogeneity among the included studies regarding sample size, countries, methods, outcomes, etc.., the random-effect model and Standardized Mean Difference (SMD) with a 95% Confidence Interval (95%CI) were used. Subgroup analysis was also carried out based on the type of educational intervention including E-learning, blended and conventional groups. Publication bias will be performed if the included studies in the quantitative analysis were 10 or more.

Results

Selection of studies

The search of five electronic databases yielded 3541 articles which were transferred to EndNote (EndNote software version X8, Thomson Reuters, 2013, New York, USA). After the elimination of duplicates, 1886 articles were screened in the first phase and 82 records were subjected to full-text assessment in the second phase. Finally, 23 articles were selected for the systematic review, and 15 studies were subjected to meta-analysis. The full text of two articles was not available. After contacting the corresponding authors, one of them emailed the full text while the other did not respond after 2 attempts. A manual search of the reference lists did not yield any new articles. The PRISMA flow diagram is shown in Figure 1.

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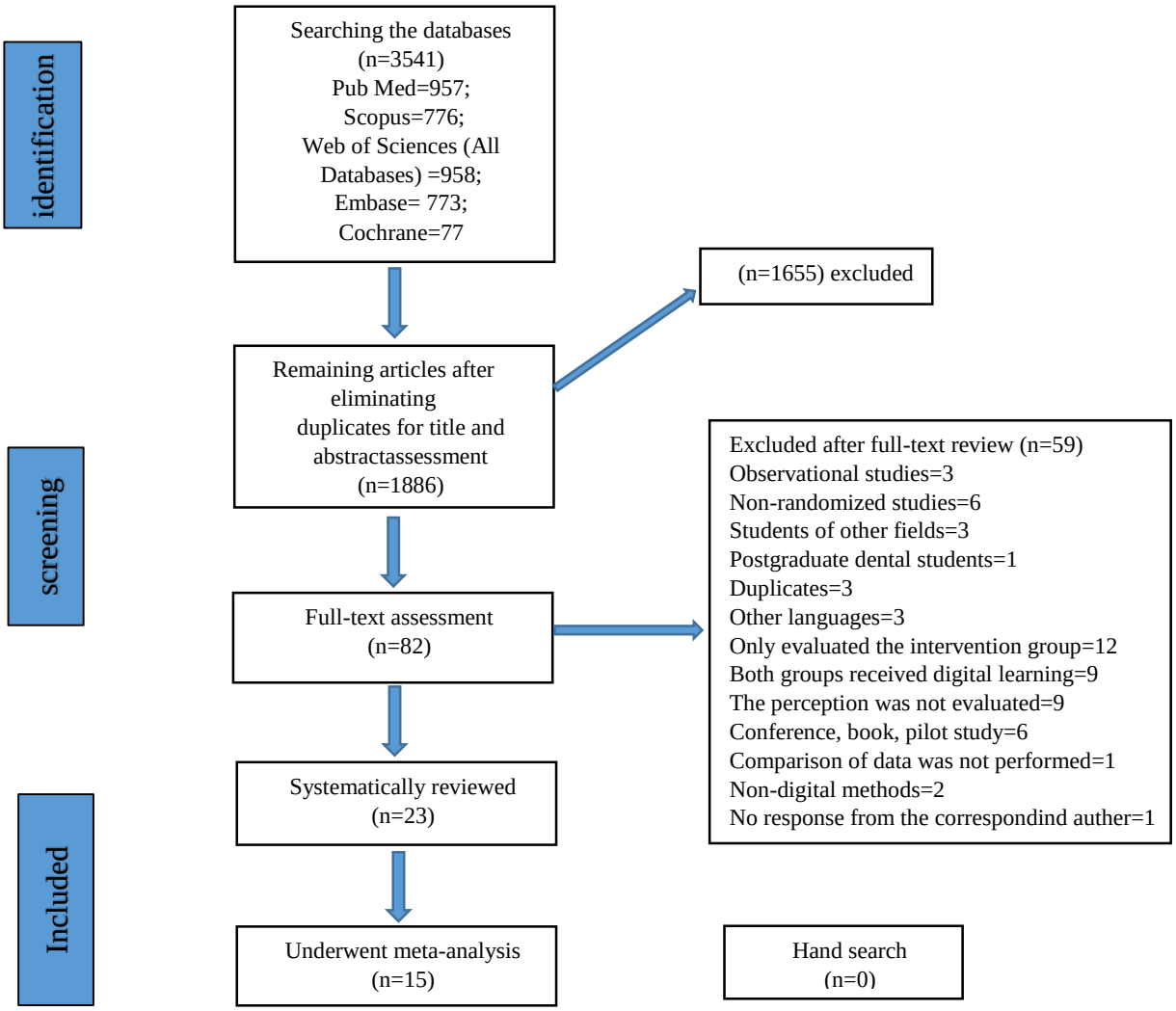

Figure 1. PRISMA flow diagram of studies selection

The control groups in different studies received conventional face-to-face learning with or without PowerPoint presentation; while the intervention groups received different digital tools and platforms through Instagram (12), computer-aided 3D simulation (26), E-learning (27), PantoDict program (27), live-video demonstration (28), E-learning software (Articulate Storyline) (15), Phone-Based Audience Response System (29), videotape (22, 30, 31), virtual 3D cast (32), online voice over captured presentation (33), plasma screen (34), Computer-Assisted Learning (35-38), digital versatile disk/versatile, compact disk (DVD/VCD) (39, 40), online education (23, 41), Learning Management System (42) and video conference (43). The characteristics of the included studies are reported in Appendix 1.

Risk of bias evaluation

Based on ROB2, 21 articles had a high risk of bias, and 2 articles had some concern risk of bias (Table 1).

Data synthesis

Meta-analysis was carried out for self-reported acquired knowledge, self-reported acquired competence, satisfaction level, and usefulness of the learning method. Subgroup analysis was also performed for E-learning (E), blended learning (B) and conventional learning (C). There were no significant differences in total and subgroup analysis among E, B and C groups regarding self-reported acquired knowledge (SMD=0.19, 95% CI: -0.20-0.58, P=0.34), self-reported acquired competence (SMD=-0.07, 95% CI: -0.57-0.43, P=0.77), satisfaction level (SMD=0.05, 95% CI: -0.42-0.31, P=0.77) and usefulness of the

learning method (SMD=0.28, 95% CI: -0.72-0.15, P=0.2). The results are shown in Figures 2 & 3.

Table1. Risk of bias assessment of articles based on each item of ROB2

No	**Author name**	**Randomization process**	**Deviation from intended interventions**	**Missing outcome data**	**Measurement of the outcome**	**Selection of the reported result**	**Overall Risk of Bias**
1	Rocha et al.2021(12)	High	Some concern	Low	Low	Low	High
2	Hai Yen Mai et al.2021(26)	High	Some concern	Low	Low	Low	High
3	Bock et al.2021(27)	High	Some concern	Low	Low	Some concern	High
4	Bock et al.2021(27)	High	Some concern	Low	Low	Low	High
5	Atik et al.2020(28)	Low	Some concern	low	low	low	Some concern
6	Jeganathan et al.2020(15)	High	Some concern	Low	Low	Low	High
7	Alharbi et al.2020(29)	Low	Some concern	Low	Low	Low	Some concern
8	Slaven et al.2019 (22)	High	Some concern	Low	Low	Low	High
9	Mahrous et al.2019(32)	High	Some concern	Low	Low	Low	High
10	Thilakumara et al.2018(30)	High	Some concern	Low	Low	Low	High
11	Kenny et al.2017(31)	High	Some concern	Low	Low	Low	High
12	Schonwetter et al.2016 (33)	High	Some concern	Low	Low	Low	High
13	Shapiro et al.2014 (41)	High	Some concern	Low	Low	Low	High
14	Bains et al.2011(23)	High	Some concern	High	Low	Low	High
15	Kavadella et al.2011 (42)	High	Some concern	Low	Low	Low	High
16	Nikzad et al.2011 (40)	High	Some concern	High	Low	Low	High
17	Nance et al.2009 (39)	High	Some concern	High	Low	Low	High
18	Peroz et al.2009(35)	High	Some concern	Low	Low	Low	High
19	Eitner et al.2008 (36)	High	Some concern	Low	Low	Low	High
20	Aly et al.2004 (37)	High	Some concern	Low	Low	Low	High
21	Mattheos et al.2003 (43)	High	Some concern	Low	Low	Low	High
22	Packer et al.2003 (34)	High	Some concern	Low	Low	Low	High
23	Hobson et al.1998 (38)	High	Some concern	High	Low	Low	High

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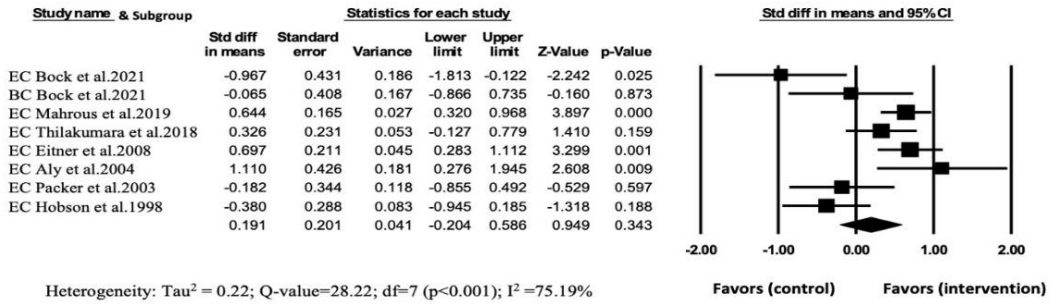
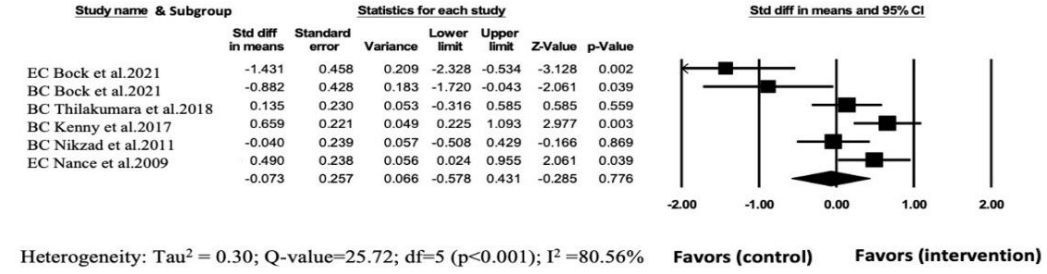
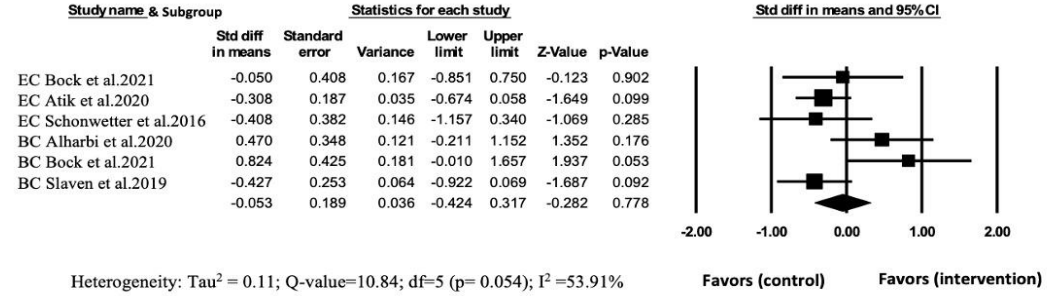


(1) Comparison of self-reported acquired knowledge among groups E, B and C

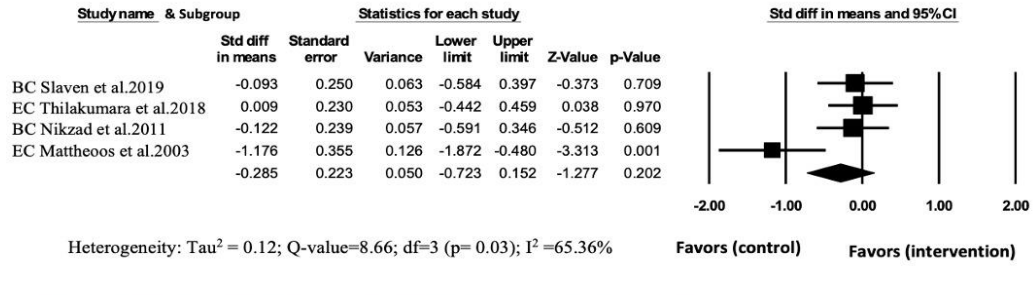


(2) Comparison of self-reported acquired competence among groups E, B and C

Figure 2. Comparison of self-reported acquired knowledge (1) and self-reported competence (2) among groups E, B and C



(3) Comparison of satisfaction level among groups E, B and C



(4) Comparison of usefulness of learning method among groups E, B and C

Figure 3. Comparison of satisfaction level (3) and usefulness of learning (4) among groups E, B and C

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The GRADE assessment

In each of the four main outcomes, the overall quality of evidence was assessed to be low by the GRADE tool. Also, since the number of articles for each outcome was less than 10, publication bias analysis could not be performed (Table 2).

Table2. Assessment of quality of evidence by GRADE

Number of studies	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Quality of evidence
Self-reported acquired knowledge						
8	Serious	Serious	Not-serious	Not-serious	n/a*	⨁⨁◯◯
Self-reported acquired competence						
6	Serious	Serious	Not-serious	Not-serious	n/a	⨁⨁◯◯
Satisfaction level						
6	Serious	Serious	Not-serious	Not-serious	n/a	⨁⨁◯◯
Usefulness of learning method						
4	Serious	Serious	Not-serious	Not-serious	n/a	⨁⨁◯◯

*Not applicable

Discussion

The aim of this study was a systematic review and meta-analysis of the perception of undergraduate dental students from digital learning vs. conventional learning. Twenty-three studies were systematically reviewed, and 15 articles were subjected to meta-analysis. Four main outcomes, including self-reported acquired knowledge (8 articles), self-reported acquired competence (6 articles), satisfaction level (6 articles), and usefulness of learning method (4 articles) underwent meta-analysis.

In the present study, concerning self-reported acquired knowledge, no significant difference was noted among E-learning, blended, and conventional groups. In some studies, (32, 36, 37) dental students reported a higher level of acquired knowledge in the E-learning group vs the conventional learning group. Reported advantages were flexibility (37), less time-consuming (36, 37), optimizing knowledge transfer and assessment (36), easy-to-customize and more economic (32). Whereas in one study by Bock et al. (27), dental students reported higher acquired knowledge in the conventional group. In their study (27), students in the conventional group confirmed that the face-to-face seminar was ideal as an introduction to the subject and more interactive.

In our study, regarding self-reported acquired competence, no significant difference was noted among E-learning, blended, and conventional learning groups. In Bock et al.'s study (27), students in the conventional group reported higher acquired competence vs. E-learning group. In the E-learning group, students complained they were not familiar with how to work with study software to formulate reports of panoramic radiographs. In Nance et al.'s study results favored to the E-learning group (39). Participants of Nance et al.'s study (39) belonged to the Internet generation (Net Gen); this generation believes that using a digital tool better meets their learning expectations than working in a laboratory, and this method has a novelty for such students. The comparison to blended learning and conventional learning, Kenny et al. (31) reported higher acquired competence in the blended learning group. They suggested that deep learning about the use of behavior management techniques did not occur without the video clips. Using video clips can standardize learning among a large group of students, which may not be simply achieved by clinical experience alone (31). Two other studies (30, 40) found no significant difference between the learning methods in this respect. Dental students mentioned video clips could not be watched repeatedly as much as required by them (30) because of the specific design of the study. In the study by Nikzad et al. (40), equipment was not available in the dormitories. Also, students did not have Persian instructions regarding how to use VCD.

In our study, regarding the level of satisfaction, no significant difference was noted among different learning modalities. The determinants of E-learning perceived satisfaction are technical system quality, information quality, service quality, support system quality, learner quality, instructor quality, and perceived usefulness (44). To increase the level of satisfaction, attention should be paid to these factors. While in the included studies, a few of these factors have been considered, and this may affect the perceived satisfaction of the students.

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In this study, regarding the usefulness of the learning method, no significant difference was noted among different learning modalities. Only one study (43) reported higher use of the learning method in the conventional group. In their study (43), students can discuss with the instructor after the classroom exam in the conventional group. Also, in their opinion, contact with the examiner during the exam may be relaxing for them and reduce some of the exam stress. Three other studies found no significant difference in this respect (22, 30, 40).

This study has several strengths. This study was the first systematic review and meta-analysis that compared undergraduate dental students' perceptions related to digital learning and conventional learning. The included studies were randomized clinical trials that had a high level of evidence. The present study follows a repeatable, logical and time-limited search strategy.

In the present study, most included studies had a high risk of bias due to lack of allocation concealment. In such educational interventions, although blinding of instructors and students (double-blind design) is not possible, allocation concealment is simply workable, which was done in only two of the included studies (28, 29). Another limitation was the use of different questionnaires and diversity in the outcomes related to dental students' perceptions, which led to high heterogeneity. It is better to design validated questionnaires to evaluate students' perceptions of future studies. It should be noted that nowadays, because of the access of almost all students to the Internet and smartphones, students' learning has become more independent and more learning opportunities have been provided through digital learning. Other limitations of the study can be mentioned as follows; small sample size (27, 29, 33, 34), only men included in the study (29), inconsistency of the data reported in the table and the text (23) and different duration of intervention (30, 35). Also, the information technology knowledge and experience of participants were not similar among intervention groups (39). Order of educational modalities in blended learning can also affect the results, which were only controlled in one study (23). The presence of different instructors (although calibrated) in three studies could have also affected the results (22, 30, 40). In some studies, students did not have access to virtual educational content outside the university (30, 40).

It is recommended to design a comprehensive and standard questionnaire to evaluate students' perception of digital learning. It is better to consider all determinants that maybe affect students' perception, including technical system quality, information quality, service quality, support system quality, learner quality, instructor quality, and perceived usefulness (44). Attitude and interest of instructors in E-learning can also affect the perception of students from E-learning, which should be considered. Considering the practical clinical nature of dentistry and the necessity of practicing on patients, further studies should focus on using simulators, virtual patients, and haptic feedback to simulate clinical scenarios.

Conclusion

No significant difference was noted among E-learning, blended and conventional groups in self-reported acquired knowledge, self-reported acquired competence, satisfaction level, and usefulness of learning method according to the opinion of undergraduate dental students. However, considering the low level of evidence, the results should be interpreted with caution.

Conflict of interest

The authors have no conflict of interest relevant to this article.

Aknowledgement

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Appendix 1. Characteristics of included studies

No	Author's name Year of publishing country	subject	Study design & sample size	Population's feature	Intervention group	Control group	outcome	scale	Statically results	Summary of finding
1	Rocha et al(12) 2021 Brazil	Oral radiology	Parallel 71	Grade: 2	E- Learning (instagram+ KAhooT) = 20 Hybrid learning (E-learning +traditional) = 19 Problem Based Learning (PBL)=16	Traditional (face to face with the aid of Power Point) = 16	1- assists learning 2- more confident 3- mre stimulated to research 4. assist in professional life 5- develop other skills.	1 = totally agree To 5 = totally disagree	1- hybrid:88.88%, traditional:71.4%, active: 95.23% 2- hybrid:77.77%, traditional:57.14% active:85.71% 3- hybrid:66.66%, traditional: 57.14% active: 71.42% 4-hybrid: 66.66 Traditional: 57.14 active:71.42 5- hybrid:66.66%, traditional:57.14%, active:76.19% were totally agreed.	The frequency of "totally agree" answers in E-learning method was higher than other methods.
2	Hai Yen Mai et al (26) 2021 Korea	Prostheses	Parallel 60	Grade: 2	LtS (Lecture to computer-aided simulation) conventional lecture followed by computer-aided 3D simulation software = 20 LwS (Lecture with computer-aided simulation) conventional lecture and computer-aided 3D simulation simultaneously=20	Conventional Lecture(L): using a textbook and 2D illustration = 20	1- Expected score: Self-assessment of expected score	90<A≤100 80<B≤90 70<C≤80 60<D≤70 F≤60	1- L group (75.7 ± 16.9) LtS (88.7 ± 10.7) LwS (89.7 ± 12.5), p-value<0.001	L group exhibited significantly lower estimates than the other groups that used the computer-aided simulation Students gave themselves a B grade in the simulation methods and a C grade in the lecture method.
3	Bock et al(27) 2021 Germany	Oral and Maxillofacial Surgery	Parallel 37	Grade: 6th semester Age: 12 participants were < 22 years, 16 participants were between 22 and 25 years , 9 participants were older than 25 years old. Male: 54% Female: 46%	E-learning = 12 Blended learning (E-learning + lecture) =13	Lecture group (regular lecture) = 12	1- self-assessment of theoretical knowledge gain and an improvement of their practical skills. 2- level of satisfaction	10-point Likert scale: 1=indicating "fully agree" To 10="totally disagree"	1- all 3 groups confirmed a theoretical knowledge gain and an improvement in their practical skills after the seminar, but there were no statistical differences in self-assessment between 3 groups. 2- lecture group: mean score = 1.58, SD = 0.64 blended group: mean score = 1.62, SD = 0.49, E-learning group: mean score = 1.67, SD = 0.47	The knowledge gain and improvement of practical skills in all 3 groups did not show a significant difference. Student satisfaction was high in all 3 groups
4	Bock et al(27) 2021 Germany	Radiology	Parallel 36	Age: 21-28 Male: 7 Female: 29	Group A (E-learning (PantoDict program) = 12 Group B: Blended learning (PantoDict + conventional) = 12	Group C: conventional (seminar) = 12	1- Improve my knowledge 2- feel confident in reporting 3- level of satisfaction	10-point Likert scale: totally disagree (1) to totally agree (10)	Group C rated the highest improvement in their knowledge but there were no significant differences between groups. p-value A, C:0.027 p-value: A, B: 0.65 p-value: B, C: 0.874 2-confident in their reporting was significantly more seen in group C than in group A, but there were no significant	The median level of students' satisfaction, knowledge gained, and self-confidence did not show a statistically significant difference between the 3 groups.

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									differences between groups B and C or between groups A and B p-value A, C:0.002 p-value: A, B: 0.19 p-value: B, C: 0.042 3-overall satisfaction in 3 groups did not show any significant differences, although group B (blended) has the best results. p-value A, C:0. 903 p-value: A, B: 0.074 p-value: B, C: 0.056	
5	Atik et al(28) 2020 Turkey	orthodontic	Parallel 116	Grade:4 Age:22 Male: 37 Female: 79	Live-Video demonstration= 58	Live demonstration=58	1- stress 2- easy to perform 3- satisfaction 4- helpful 5- adequacy 6- easy to understand	5-point Likert scale: 1-strongly disagree to 5-strongly agree	1- control: 29.3% Intervention: 41.4% p-value:0.21 2- control: 12% Intervention: 12.1% p-value:0.17 3- control: 25.8% Intervention: 17.2% p-value:0.10 4- control: 75.8% Intervention: 70.7% p-value:0.42 5- control: 46.6% Intervention: 48.3% p-value:0.87 6- control: 65.5% Intervention: 65.5% p-value:0.87	There were no statistical significances between 2 groups in all the context. The live-video technique was found to be as effective as a conventional live demonstration for orthodontics
6	Jeganathan et al (15) 2020 England	Orthodontic	Parallel 70	Grade: 4 Age: 23.1 Male: 41 Female: 29	Blended group (Seminar+ E-learning source articulate storyline) -34	Traditional group (Seminar) = 36	1- rating the method of teaching 2- learning success 3-satisfaction 4-motivation 5-enjoying	Rating the teaching method with the scale: very bad, bad, neither, good, very good Likert scale of 1-5: 1-strongly disagree to 5-strongly agree	1- Blended group:82%, control group: 74% rating the teaching as “very good". 2- 94% in both groups. 3- nearly all of the students (99%) "agreed" or "strongly agreed" that they were satisfied with the teaching they received. 4-97% of students "agreed" or “strongly agreed" that this teaching session has motivated them to look up the topic. 5- 94% of the students "agree" or" strongly agreed" that enjoyed this teaching method.	99% of students were satisfied with both teaching methods. Most students rated learning success, enjoyment and motivation as good and very good. But P-value was not mentioned.

7	Alharbi et al (29) 2020 Saudi Arabia	Orthodontic	Cross-over 34	Grade: 4 Age: 23.27 Male:34	PB-ARS group: Phone-Based Audience Response System as an adjunct during the PowerPoint presentation + lecture = 17	Conventional group (lecture by PowerPoint) = 17ACA	1- rate the level of satisfaction 2- prefer PB-ARS	0-1= strongly disagree 2-4= disagree 5= neutral 6-8= agree 9-10= strongly agree	1- PB-ARS: 90%, CG: 83% p-value: 0.18 2- 76.7% preferred the use of PB-ARS during lecture	In terms of overall satisfaction level: there was no statistically significant difference between the 2 groups. The majority of participants preferred the use of PB-ARS during lectures.
8	Slaven et al (22) 2019 United States	Pediatric dentistry (BGT)	Parallel 96	Grade:2 Age:22-31 Male: 54 Female: 42	Contemporary instruction (CI): simulated a flipped classroom and consisted of a micro lecture (20-minute voiceover PowerPoint lecture) = 32 TIV (Traditional instruction with video): PowerPoint + videos + lecture = 32	Traditional struction without video (TI): only a PowerPoint lecture (50 min) = 32	1- course satisfaction 2- students' perceptions of the usefulness of each method	Rating for course satisfaction was from: 1=extremely dissatisfied to 4=extremely satisfied. Rating for module usefulness was from: 1=not useful at all to 4=extremely useful.	1- CI :3.25, TI :3.19, TIV :3.03 p-value: 0.093 2- CI :3.31, TI :3.19 TIV :3.06 p-value: 0.71	All three groups scored more than 3 on the Likert scale in terms of usefulness (p- value= 0.7) and satisfaction (p-value= 0.09), and the difference was not statistically significant.
9	Mahrous et al (32) 2019	United States	Cross-over 77	Grade: 4	virtual 3D exercises = 77	Traditional 2D paper exercises = 77	1- help to understand. 2- easier to design RPD. 2- manipulating 3D casts was easy. 3- like to involve a 3D cast in the future.	Likert scale of 1-5: 1-strongly agree to 5-strongly disagree	1- 69% 2- 63% 3- 96% 4- 75.3% were "strongly agreed" and "agreed" with a 3D cast. p-value<0.0001	There was a statistically significant difference in students' preference for 3D casts. (p-value <0.0001)
10	Thilakumara et al(30) 2018 Srilanka	Dental prostheses (arranging tooth)	Parallel 76	Grade: 322	video demonstration with printed study guide = 40	Live demonstration (20 min) with printed study guide = 36	1-feeling stress 2-more confident 3-more practical 4- improving understanding		1- p-value:0.39 2- p-value: 0.56 3- p-value: 0.97 4- p-value: 0.16	There were no statistical significance regarding feeling stress, confidence, practical and improving understanding between 2 groups. (Data was not available and only p-value was reported)
11	Kenny et al(31) 2017 England	Pediatric dentistry (local anesthesia)	Parallel 86	Grade: 4	Standard lectures and small group tutorials with the video clips (VC) via a password-protected server = 43	Standard lectures and small group tutorials = 43	1-students' confidence at baseline 2-students' confidence 4 months later	Likert scale of 1-5: 1-strongly agree to 5-strongly disagree	1- control:45%, VC:60%, P-value: 0.003 2- control: 40%, VC > 70%, P-value: 0.001	There was no statistically significant difference in the level of confidence between baseline and 4 months in the control group. In the intervention group, there was a statistically significant difference in the level of confidence at 4 months (higher) and baseline. There was a statistically significant difference between 2 groups.
12	Schonwetter et al(33) 2016 Canada	Endodontic obturation	Parallel 28	Grade: 2 Age: 20-34 years (M=25.46, SD=3.47). Male:21 Female:7	Online voice-over screen-captured presentation = 14	Traditional (face-to-face lecture with Power Point) = 14	1- Students' satisfaction 2- students' recommendation 3- Students' perception of success 4-Students' perception of control	1=poor to 5=excellent	1- online lecture group: M=3.15, SD=1.35, traditional group: M=3.64, SD=0.67 p-value: 0.29 2- online lecture group: M=3.08, SD=1.32, traditional group: M=3.64, SD=0.81 p-value: 0.24	There were no statistical differences in students' satisfaction, recommendation, success and control about their learning experience between 2 groups.

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									3- online lecture group: M=2.92, SD=1.04 and traditional group: M=3.36, SD=0.51 p-value: 0.21 4- online lecture group: M=3.38, SD=1.61 and traditional group: M=3.09, SD=0.70 p-value: 0.58	
13	Shapiro et al(41) 2014 United States	Pediatric dentistry (Child abuse recognition and reporting	Parallel 72	Garde: 2	Interactive online training module group (OG) = 36	Traditional lecture group (LG) 50 minutes = 36	1- Engaging 2- Adequately preparation for the final exam	1=strongly disagree to 5=strongly agree	1- LG: 88.9%, OG:66.7%. 2- LG: 55.6%, OG:47.3% strongly agreed or agreed.	
14	Bains et al(23) 2011 England	Orthodontic	Parallel 90	Grade: 4 Age: 21-23 Male: 37 Female: 53	EL (online tutorial) =22 BL1 (on line tutorial first, then teacher-led tutorial =14 BL2 (teacher-led tutorial first, then online tutorial= 18	F2FL (teacher led tutorial) =36	1- Acceptance of the method 2- Rate the method 3- stimulate to look up the topic further 4- Recommend	2- Likert scale1-5: 1=very bad to 5=very good 3- Likert scale 1-5: 1=strongly disagree to 5= strongly agree 4- Yes /Maybe / No	1- Mean mm (S.D.) for groups: F2F:70.75 (24.48), EL:83.29 (17.99), BL1:93.07 (10.75), BL2:83.94 (13.33). p-value=0.002 2- 80% rated the intervention as good or very good, p=0.17 3- 69% of students agree that their method of learning stimulated them. p-value=0.059 4- F2F and BL were the most likely methods to be recommended but p-value=0.36	BL1 was the most, whilst F2FL was the least accepted (BL1>BL2>EL>F2F). 80% of students rated the methods good or very good. 69% of students agreed that this method stimulated them to look up the topic further. E-learning alone was not recommended by students.
15	Kavadella et al(42) 2011 Greece	Radiology	Parallel 47	Grade: 10th semester Male: 14 Female: 33	Blended learning (face-to-face + learning management system, LMS) = 24	Conventional group (lectures+ PowerPoint) = 23	1- Easy to understand 2- Overall opinion	Likert scale: 1 = very negative to 5 = very positive opinion.	1- Conventional group: 4.09 (0.733), blended group:4.13 (0.680). 2- Conventional group:4.43 (0.662), blended group:4.46 (0.509),	Considering the easiness to understand and the overall opinion on the course, both groups had a positive opinion.
16	Nikzad et al(40) 2011 Iran	Dental prostheses	Parallel 70	Grade:3	Group B: live presentation method + VCD + study guide = 35	Group A: live presentation method = 35	1- Stress feeling during the tooth preparation phase. 2- Stress feeling during making a temporary crown 3- Stress feeling during laboratory procedures. 4- Adequacy 5- Helpful for clinical practice. 6- confidence	1,2,3= Likert scale: No stress, stressful, little stress. 5-point Likert-scale	Mean Rank: 1- Group A:35.31, group B: 35.59. p=0.931 2- Group A:33.51, group B: 37.49. p=0.371 3- Group A:35.86, group B: 35.14. p=0.869 4- Group A:37.84, group B: 33.16. p=0.239 5- Group A:39.41, group B: 31.59. p= 0.61 6- Group A:35.86, group B: 35.14. p=0.869	There were no statistically significant differences between 2 groups in all contexts.
17	Nance et al(39) 2009 United States	Dental morphology	Parallel 73	Grade: 1 Male: 38 Female: 35	DVD-only group = 37	Traditional group = 36	1- students' self-assessment grade 2- the teaching method worked well 3- improve the ability for self-directed learning	1- Grading descriptor rubrics: 4.0 =excellent, 3.5=outstanding, 3.0=good, 2.5=above average, 2.0=average, score<2 = failed	1- Traditional group: 3.1 ±0.1, DVD-Only: 3.0 ±0.1. faculty actual mean grades (2.2 for each group) P-value<0.006. Spearman's correlation 0.32	There was also a statistically significant weak correlation difference between students' self-assessments and faculty grades.

							4- Adequacy of the method. 5- enjoyment	2,3,4,5: Likert scale: agree, neutral, disagree	2- TG: 12/36, DVD:22/37 P-value<0.05 3- TG:15/36, DVD: 22/37, P-value<0.05. 4- TG:15/36, DVD: 28/37, P-value<0.01. 5- TG: 10/36, DVD: 24/37, P-value<0.002.	All examined outcomes were in favor of DVD group significantly.
18	Peroz et al(35) 2009 Germany	Dental prostheses	Parallel 85	Grade: 1st & 3rd preclinical semester Male: 29 Female:56	CAL: computer assisted learning (68 minutes) = 48	Lecture: face-to-face with PowerPoint (60 minutes) = 37	1- enjoyment 2- suitable content	10-point Likert scale: 0=no agreement, to 10=full agreement	1- P-value < 0.001 2- P-value<0.001	The students enjoyed the oral lecture significantly more than the CAL online tool. The lecture group also evaluated the structure and suitable content of the oral lecture as significantly better
19	Eitner et al(36) 2008 Germany	Oral maxillofacial implantology	Parallel 95	Grade: 3rd and 4th clinical semesters Age: 24.2 Male: 48 Female: 47	Group B: CAL (MobiTED, a CAL/CAT-based interactive communication system) = 48	Group A: Conventional method (a professor in front of the students) = 47	1- Level of attentiveness 2-Involvement 3-Knowledge gain 4-Attractiveness 5- Quality	Visual analog scales (VAS) ranging from 0 (very poor) to 10 (very good)	Median VAS: 1- Group A: 7.4, Group B: 8.2. 2- Group A: 6.8, Group B: 8.2. 3- Group A: 6.6, Group B: 7.4. 4- Group A: 6.8, Group B: 8.2. 5- Group A: 6.8, Group B: 8.1. for all of them p-value<0.001	The median level of attention, involvement, knowledge gain, attractiveness and quality of the seminar in the CAL / CAT group was significantly better.
20	Aly et al(37) 2004 Belgium	Orthodontic	Parallel 26	Grade: 6	CAL (Multimedia courseware package) 90 minutes = 15	Standard lectures with PowerPoint and blackboard 90 minutes = 11	The extent of understanding of the instructional content concerning multidisciplinary orthodontic treatment		Standard lecture: mean score=4.7 SD= 3.4 CAL: mean score= 7.9 SD=2.6 p-value=0.01	CAL group scored significantly better
21	Mattheos et al(43) 2003 Switzerland	Periodontology	Parallel 39	Grade: 2	Video conference = 24	Standard classroom = 15	1- effective for learning 2- level of motivation 3- self-assessment	1= not effective, to 9=very effective	Median score: 1- classroom:8 videoconferance:6 p-value:0.001 2- classroom:8 videoconferance:6 p-value:0.002 3- classroom:6 videoconferance:5 p-value>0.05	Students seem to prefer classroom assessment
22	Packer et al(34) 2003 England	Dental prostheses	Cross-over 17		Plasma screen = 17	Demonstration live at the workbench = 17	1-enable to see all technical procedures better 2- understand the procedure 3-enable to perform the technical procedure 4- would not be as useful as a live demonstration.	1,2,3 = Yes / No 4=Likert scale: strongly agree, to strongly disagree	1- Work-bench: 10/17, Plasma-screen: 17/17 said Yes. (p-value:0.04) 2- Work-bench:17/17, Plasma-screen: 15/17 said Yes. (p-value:0.6) 3-Work-bench:16/17, Plasma-screen: 16/17 said Yes. (p-value:1) 4- 11/17 of students (64.7%)	Only the vision of all procedures was significantly improved and in other outcomes, no significant difference was observed. 64.7% of the students agreed that the demonstration live method was better than the plasma screen method. The students suggested that if the plasma method is used, it is better to accompany the video conference to interact with the teacher.
23	Hobson et al(38) 1998 England	Orthodontic	Parallel 49	Grade: 4	CAL (text-based computer assisted learning) = 25	TUT (Seminar-based) = 24	1-The aims of the teaching were achieved. 2- The teaching was informative	Likert scale of 1-5: 1-strongly agree to 5-strongly disagree	1- TUT:12/24, CAL:7/25 strongly agreed or agreed. P-value=0.15 2- TUT:20/24, CAL:13/25	In terms of achieving teaching goals, being informative, and rating, 2 methods were similar. But in the tutorial method, students were

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							3- Stimulate to look for more information. 4-Rate the method	Rating ranged from "very good" to "very poor"	strongly agreed or agreed. P-value=0.19 3- TUT:12/24, CAL:3/25 strongly agreed or agreed. p-value: not reported 4- TUT:17/24, CAL:8/25 rated very good or good. P-value=0.66	stimulated to look for more information.

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