Evaluation of technology-based learning by dental students during the pandemic outbreak of Corona virus disease 2019

Running title: Dental online learning during COVID-19 pandemic

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Abstract

Introduction: Although technology-based learning (TB-learning) has been accepted as an efficient educational tool in the field of dentistry, evaluation of TB-learning in non-prepared situations such as pandemics has not been fully investigated. This study aimed to evaluate different aspects of TB-learning among undergraduate dental students during the pandemic outbreak of COVID-19.

Materials and methods: Dental students in selected Iraqi universities (University of Baghdad, University of Sulaimani, and Dijlah University College) were invited to join the study. A questionnaire was created using a Google platform and answered by students. Satisfaction and attitude toward TB-learning plus total evaluation scores for lecturers were examined.

Results: A total of 832 out of 1800 dental students participated in the study. The majority of participants have basic (40.7%) and intermediate (47.5%) computer skills and more than half of them lack any experience in TB-learning. The overall satisfaction and positive attitude toward TB-learning was less than 50%. Students at final grade, with advanced computer skills and TB-learning experience showed higher satisfaction (OR: 3.031, 2.876, 3.644, respectively) and a more positive attitude (OR: 3.172, 3.035, 3.477, respectively) toward TB-learning than those at earlier grades. Total evaluation scores for lecturers were higher among females (11.5± 5.8) than males (9.9± 7.2) as well as among participants at final grade (14.0± 6.2), with advanced computer skills (13.8± 6.1), and TB-learning experience (16.2± 6.0).

Conclusions: Dental students demonstrated low-moderate satisfaction and positive attitude toward TB-learning and the quality of material presented to them. Integrating TB-learning into

the dental education curriculum is an essential step in enhancing the acceptance of TB-learning in the future.

Keywords: Online learning, Distance learning, Dental education, COVID-19.

Introduction

In December 2019, coronavirus disease 2019 (COVID-19) was recognized as an acute respiratory infectious disease in Wuhan city, China. Later, on 11 February 2020, COVID-19 was announced by the World Health Organization (WHO) as a pandemic with high mortality and morbidity rates[1,2]. The mechanism of spreading the virus is mainly dependent on direct contact and airborne droplets, even from asymptomatic carriers, and the rate of transmission is highly increased in crowded places such as universities[1]. Therefore, drastic measures, mainly focusing on restricting social gatherings, were taken at international and national levels to reduce the risk of transmission[3]. Accordingly, strict recommendations were suggested by The United Nations Educational, Scientific and Cultural Organization (UNESCO), Office of the United Nations High Commissioner for Human Rights (OHCHR), the International Federation of the Red Cross and Red Crescent Societies (IFRC), and WHO[4,5]. These organizations urged countries to provide

education settings that would be well prepared, acceptable, adaptable and accessible to all at schools and universities following temporary closures during pandemic disasters. The intention was to promote distant online learning and various delivery strategies[4-7].

Technology-based learning (TB-learning) is a learning approach that relies on incorporation of information and communication technologies such as visual media, digitalized content, interactive video tools, graphs, or web-based interaction to suit the learning style of students and enhance their ability to interact with the learning process, regardless of time and place[8]. It is broadly applied as an efficient learning and training tool in the medical sciences, including dental education[9-13]. In terms of pedagogical impact, TB-learning has the potential to shift the educational process towards an active learner environment compared to the passive role in the conventional classroom environment[14]. Distance learning has been shown to have a positive influence on students' learning outcomes such as learning satisfaction[15]. In this context, social media including WhatsApp and other applications such as Google class, Edmodo and Zoom can be valuable tools in conveying online learning[16]. Furthermore, it has been shown that a combination of the distance TB-learning and conventional styles brought optimum student performance and satisfaction[17]. However, several pros and cons of TB-learning have been reported in literature that raise questions regarding whether it is superior to or even as effective as conventional classroom learning. Additionally, emergence of abrupt circumstances that make distance learning to be very challenging might lead to inequality among individuals[18]. The evaluation of distance TB-learning in the non-prepared environment of transition from the conventional classroom learning style during unexpected circumstances such as pandemic disease has yet to be investigated.

In light of COVID-19 infection-control recommendations, the emergency operations center and health authorities in Iraq have decided to temporarily close all the educational institutions and implement distance TB-learning as an indispensable alternative educational tool. Therefore, a questionnaire-based survey was conducted to evaluate the satisfaction of undergraduate dental students in selected Iraqi universities towards different aspects of TB-learning during the pandemic outbreak of COVID-19.

Materials and methods

Study design

This study was a questionnaire-based online survey to evaluate TB-learning experience among dental students in selected Iraqi universities (University of Baghdad, University of Sulaimani, and Dijlah University College). The questionnaire was created using a Google platform, then the link was sent to the students via their email accounts for them to complete the questionnaire anonymously. This study was approved by the local ethics committee in the Department of Periodontics, College of Dentistry, University of Baghdad in accordance with the Helsinki declaration for human researches. Consent was obtained from each student by including a welcome message that explained the purpose of this study and a consent statement at the beginning of the questionnaire. This study followed the guidelines of the STROBE statement for writing observational studies[19].

Sample size

The targeted sample was dental students in all grades from the three selected universities (1800 students). Calculation of the sample size was performed according to the following formulas:

Sample Size = (Distribution of 50%) / ((Margin of Error% / Confidence Level Score)2)

Confidence level= 1.96 (for confidence level of 95%), margin of error= 0.05.

True Sample = (Sample Size X Population) / (Sample Size + Population – 1)

According to the results, the required sample was 306 subjects which was then multiplied by 4 to allow a 25% response rate[20]. Thus, the final sample size was 1224 which represented the number of students who had received the questionnaire after randomly selecting these accounts using a simple randomization method.

Design of the questionnaire and score calculation

The questionnaire was designed and drafted depending on already published questionnaires in the English language and no attempt was made to translate it to native language[8]. The questions were split into two sections. The first section dealt with demographic data on the participants, including age, gender, grade, computer skill level, and experience level in TB-learning. The second section consisted of evaluation questions and was subdivided into three parts. The first part (questions #1 to #8) was dedicated to "TB-learning satisfaction", while the second part (questions #9 to #17) was designed to evaluate participants' "attitude towards TB-learning". The third part was aimed at "evaluating the lecturers" (questions #18 to #24) and the possible answers were presented on a Likert scale. Elements of the questionnaire are illustrated in table 1.

As the questionnaire's design obliged the participants to answer all the questions, the returned electronic forms were all completed.

Statistical analysis

The data were not evenly distributed; therefore, nonparametric analyses were used for comparing different variables. For part I and II, Chi-square test was used because the data were expressed as frequency. In addition, the association of different bi- and multivariant variables with positive answers (Yes) for these parts was determined by calculating the odd ratio (OR) at 95% confidence interval (CI). Analysis of Likert-based questions (third part) was performed by using the Mann-Whitney U test and Kruskal-Wallis test followed by *post-hoc* analysis. All statistical methods were performed by using GraphPad Prism (Version 8.4.0, USA). The statistical significance level was set at $p < 0.05$.

Results

Eight hundred and thirty-two students (357 male and 475 female) with mean age of 20.95 ± 1.65 years (ranging from 17 to 26 years) participated in the study. The number of respondents represented 68% of the calculated sample size (1224), which was considered as a satisfactory response rate. The percentages of students at the different grades of dental education were as follows: grade 1= 20.8%, grade 2 = 10.3%, grade 3 = 23.1%, grade 4=28.4% and grade 5=17.4%. The overall proportions of positive and negative responses to each question in parts I and II of the questionnaire are shown in Figure 1. The majority of participants had basic (40.7%) and intermediate (47.5%) computer skills and more than half of them lacked any experience in TB-learning, while only 7.6% of participants were experienced in TB-learning (Table 2).

TB-learning evaluation (Part I of the questionnaire) varied among the participants; there was a statistically significant difference between males and females ($p < 0.001$), with a higher proportion of females expressing satisfaction with TB-learning (OR 1.238). Furthermore, students who had progressed further in their education showed increased satisfaction with TB-learning ($p < 0.001$). Both computer skills and TB-learning experience were shown to have a statistically significant impact on overall TB-learning evaluation ($p < 0.001$ for both). The higher the computer skills and TB-learning experience, the greater the satisfaction (Table 3).

Likewise, there was a statistically significant difference in overall attitude toward TB-learning amongst participants (part II of the questionnaire). Females were more appreciative than males of TB-learning ($p < 0.001$, OR 1.338). Students' grade level was also shown to have a significant

effect on attitude toward TB-learning (p< 0.001). Moreover, there were statistically significant differences between students with different computer skills (p< 0.001) and TB-learning experience (p< 0.001). Those with higher computer skills showed greater appreciation of TB-learning. Similarly, the more experience of TB-learning, the more positive the attitude towards TB-learning (Table 4).

Evaluation of lecturers by students was another aspect examined in this study (Part III of the questionnaire). Gender was shown to have a statistically significant effect on the overall evaluation of lecturers by students (p<0.003), with females giving higher evaluations (11.5± 5.8) than males (9.9± 7.2). Furthermore, student's grade level was shown to have a statistically significant impact on the evaluation of lecturers by the students. The higher the grade, the higher the total evaluation score for lecturers. Finally, variations in computer skills and TB-learning experience were shown to have a statistically significant effect on the students' total evaluation scores for lecturers (Table 5).

Discussion

The emergence of an unexpected pandemic disease imposes obligatory changes on the normal daily activities and lifestyle, including the teaching processes in educational institutes. Such a sudden transition in the teaching mode creates challenges in terms of delivering the required scientific materials to the students. Current reviews have shown that, like qualified dentists, dental students are at high risk of infection as they closely manage patients as part of their academic learning[21,22]. Thus, this study was designed to evaluate different aspects of TB-learning experience amongst dental students in three Iraqi universities.

Previous studies have indicated that although TB-learning is well-accepted among dental students, less than half of the participants expressed positive perceptions of TB-learning[23]. Similarly, more just over 50% of the participants in the current study were not satisfied with their TB-learning experiences. However, significant variations within different demographic variables were observed. Satisfaction and positive attitude towards TB-learning seem to be positively associated with gender, grade, computer skills, and previous experiences of online learning. These results were consistent with a previous study conducted among dental students in Croatian universities[8]. In terms of gender, females showed higher satisfaction and a more positive attitude than males towards TB-learning, which is similar to the suggestion by other studies that females are more willing to engage in TB-learning[24,25]. Nevertheless, other studies have rejected the role

of gender in relation to acceptance of or positivity towards TB-learning methods[26,27]. These differences could be due to variations in the sample size and assessment methods.

Further, the attitudes of 5th year students towards TB-learning and technical experience were significantly more positive than among their younger peers[28]. Lack of technical skills is among the leading obstacles that adversely affect the TB-learning process[29]. Responses of dental students in another study have showed that their perception of TB-learning was related to the degree to which they possessed the essential computer skills and permanent access to the internet[30]. These results were in line with the finding by our survey.

Computer and information technology (IT) skills potentially strengthen the connection between individuals and the TB-learning concept. In addition, it enhance their dexterity in using different platforms and applications and vice versa[31]. Although social media can offer effective tools in the TB-learning process, most of the respondents considered social media to be unhelpful. A previous study concluded that the curriculum must be pre-defined and well-structured to ensure the effectiveness of these tools for professional TB-learning[16], while the failure to meet these requirements could explain the negative responses in our study.

Conflicting results have been previously reported regarding satisfaction with TB-learning, with the drop-out rate among participants being not significantly different from that in face-face settings[32]. Meanwhile, another study has indicated a higher attrition rate for online courses than conventional learning[33]. This could be attributed to overlapping in the timing of online lectures with personal and normal daily activities[34]. However, in general, students' perceptions of satisfaction with TB-learning programs are influenced by several factors, most importantly the quality of the course[35]. Support for this notion was reflected by the participants' emphasis on the need to improve the quality of the given online lectures. Furthermore, most of them agreed that combining TB-learning with classic classroom learning is the best approach to achieve the goals of the educational process. This finding agrees with results obtained from a previous systematic review and meta-analysis[17] and other surveys conducted on medical and dental students[29,36,37]. However, no significant difference was observed between dental students receiving conventional learning only and those with additional access to TB-learning[38].

Evaluation of the lecturers showed that the mean attitude of females towards e-lecturers was significantly higher than that of their male counterparts, which is consistent with results from a previous analytic cross-sectional study which suggested that females are more teacher-oriented

than males[39]. Also, the mean of e-lecturer evaluation increased significantly in relation to the variables investigated. Creativity, design and aesthetic presentation of the online material, and live interaction with the students are among the lecturer-related factors that positively and significantly affect the success of the online courses[40,41]. Indeed, attitude towards e-lecturers and the quality of the lectures are fundamental factors in judging the success of TB-learning[29]. Preparation of a lecture delivered through cyberspace is a real challenge to the teachers and IT knowledge and proper infrastructure are paramount requirements[39] in terms of compensating for the lack of physical presence and dynamic interaction of the conventional learning environment. The sudden transition to TB-learning, with no preparations, negatively affected the performance of the lecturers. In addition, the TB-learning programs were not seriously considered as an integral part in the educational process or their application might have been very limited in many universities. These problems were further aggravated by massive demand for constant use of the web, as indicated by the increase in inbound and outbound traffic, which potentially limited the teachers' ability to offer better-quality presentations that usually require high bandwidth in order to achieve online availability. All the previously mentioned reasons could compromise the quality of online lectures and performance of e-lecturers.

Like other observational studies, this study has inherent limitations whereby only associations with certain variables can be determined but not the cause-effect relationship. Also, the current survey focused on evaluating online lectures for undergraduates only. Thus, assessment of other aspects of distant learning, e.g. webinars, and interactive tutorials, and postgraduate online courses should be considered in the future studies. Furthermore, the results of this study were compared to previous literature studies published in normal situations rather than a crisis period, which could have introduced some bias to the responses, especially regarding depression and anxiety associated with the compulsory social restrictions.

Conclusions

In general, the results of our study showed a low-moderate degree of satisfaction and positive attitude towards TB-learning and the quality of presentation of the scientific material. However, COVID-19 associated events have highlighted the importance of improving IT and computer skills among students and teaching staff members to make them better prepared for similar crises that may happen in the future. This can be achieved by upgrading the curricula at all academic

levels to include IT and computer sciences on a broader basis. Also, it is recommended that TB-learning be accredited as a compulsory subject alongside the classical classroom curriculum.

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TABLE 1 Elements of the questionnaire

• Age:					
• Gender:		Female		Male	
• Grade:	1st	2nd	3rd	4th	5th
• How would you describe your skills in using the computer?		Basic	Intermediate	Advanced	
• How would you rate your experience in TB-learning?	No experience		Fair experience	Advance experience	
Part I (TB-learning evaluation)					

1. Do you think that TB-learning methods achieved the expected learning objectives?	Yes	No
2. Do you think that TB-learning can substitute for traditional ways of learning?	Yes	No
3. Watching videos during class makes me feel sleepy	Yes	No
4. Online tutorials helped me to get involved in and understand TB-learning	Yes	No
5. Modern education is inconceivable without computer technology	Yes	No
6. TB-learning provides the possibility of easier communication with my lecturers and colleagues	Yes	No
7. Group discussion and assignments in the e-classrooms make me think more about the topics	Yes	No
8. Websites help my learning	Yes	No

Part II (Attitude towards TB-learning)

9. I have internet and daily internet access	Yes	No
10. Social media helped me during TB-learning	Yes	No
11. Virtual communication with my colleagues and professors through Google classrooms and other platforms is boring, I would like to communicate with them in person	Yes	No
12. The lectures that have been given during e-courses were more useful than traditional lectures	Yes	No
13. It is better to combine TB-learning and traditional learning in the education process (blended learning)	Yes	No
14. Online lectures need further improvement to support the learning process	Yes	No
15. I believe that the institutional technical support is adequate for me to adopt TB-learning	Yes	No
16. I access the internet on a daily basis to check updates and announcements	Yes	No
17. Have you been adapting well to the shift from traditional learning to TB-learning?	Yes	No

Part III (Lecturer evaluation)

18. The lecturers clearly explain the topics

Strongly agree　　　Agree　　　Neutral　　　Disagree　　　Strongly disagree

19. The lecturers use the available online tools efficiently

Strongly agree　　　Agree　　　Neutral　　　Disagree　　　Strongly disagree

20. The lecturers were motivating and encouraging you to use TB-learning approach

Strongly agree　　　Agree　　　Neutral　　　Disagree　　　Strongly disagree

21. The lecturers were adequately communicating with you using social media applications

Strongly agree　　　Agree　　　Neutral　　　Disagree　　　Strongly disagree

22. The lecturers were taking your feedback about issues that faced you during TB-learning into consideration

Strongly agree　　　Agree　　　Neutral　　　Disagree　　　Strongly disagree

23. The lecturers replied to your questions sufficiently

Strongly agree　　　Agree　　　Neutral　　　Disagree　　　Strongly disagree

24. Overall, the lecturers were effective in helping you during TB-learning

Strongly agree　　　Agree　　　Neutral　　　Disagree　　　Strongly disagree

TABLE 2 Demographic background of participants (First section of the questionnaire)

Variables	
Average age (years)	20.95±1.65
Age range (years)	17- 26
	N (%)
Gender	
Male	357 (42.9)
Female	475 (57.1)
Grade	
1st	173 (20.8)
2nd	86 (10.3)
3rd	192 (23.1)
4th	236 (28.4)
5th	145 (17.4)
Computer skills	
Basic	339 (40.7)
Intermediate	394 (47.4)
Advanced	99 (11.9)
TB-learning experience	
No experience	464 (55.8)
Fair	305 (36.7)
Experienced	63 (7.6)
Total	832 (100)

TABLE 3 Comparing the overall TB-learning satisfaction responses of participants with their demographic background

Variables	Positive N (%)	Negative N (%)	p value*	OR†
Gender				
Male	1037 (36.3)	1819 (63.7)	< 0.001	
Female	1572 (41.4)	2228 (58.4)		1.238
Grade				
1st	367 (26.5)	1017 (73.5)		
2nd	293 (42.6)	395 (57.4)		2.056
3rd	527 (34.3)	1009 (65.7)	< 0.001	1.447
4th	816 (43.2)	1072 (56.8)		2.109
5th	606 (52.2)	554 (47.8)		3.031
Computer skills				
Basic	918 (29.1)	2234 (70.9)		
Intermediate	1262 (46.5)	1450 (53.5)	< 0.001	2.118
Advanced	429 (54.2)	363 (45.8)		2.876
TB-learning experience				
No experience	1099 (29.6)	2613 (70.4)	< 0.001	

Fair	1205 (49.4)	1235 (50.6)		2.320
Experienced	305 (60.5)	199 (39.5)		3.644
Total	2609 (39.2)	4047 (60.8)		

* Significant at p< 0.05 by Chi-square test

† Odds ratio at 95% confidence interval

TABLE 4 Comparing the overall attitude responses of participants towards TB-learning with their demographic background.

Variables	Positive N (%)	Negative N (%)	p value*	OR†
Gender				
Male	1388 (43.2)	1825 (56.8)	< 0.001	
Female	2156 (50.4)	2119 (49.6)		1.338
Grade				
1st	486 (31.2)	1071 (68.8)		
2nd	359 (46.4)	415 (53.6)		1.906
3rd	787 (45.5)	941 (54.5)	< 0.001	1.843
4th	1142 (53.8)	982 (46.2)		2.563
5th	770 (59)	535 (41)		3.172
Computer skills				
Basic	1242 (35)	2304 (65)		
Intermediate	1749 (57.3)	1302 (42.7)	< 0.001	2.492
Advanced	553 (62.1)	338 (37.9)		3.035
TB-learning experience				

No experience	1502 (36)	2674 (64)		
Fair	1667 (60.7)	1078 (39.3)	< 0.001	2.753
Experienced	375 (66.1)	192 (33.9)		3.477
Total	3544 (47.3)	3944 (52.7)		

* Significant at p< 0.05 by Chi-square test

† Odds ratio at 95% confidence interval

TABLE 5 Comparing total lecturer evaluation scores of participants with their demographic background (first section of questionnaire)
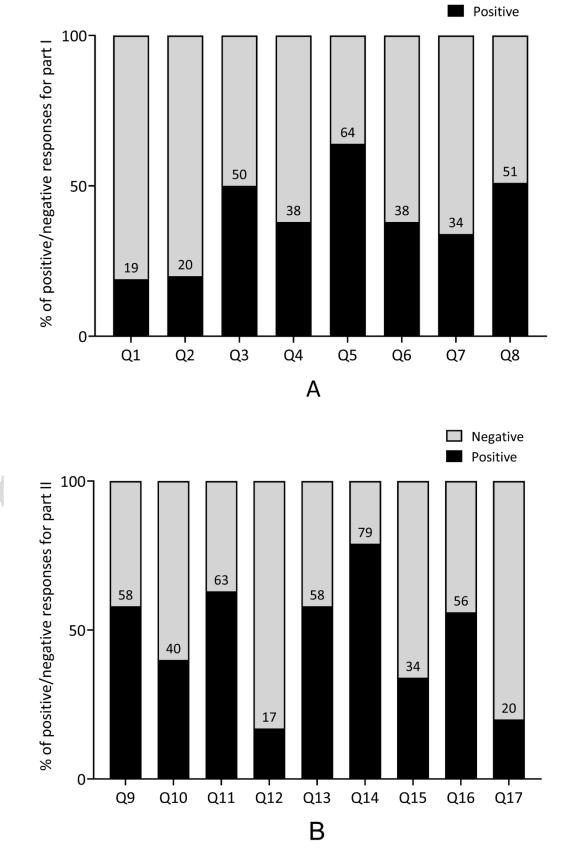
Variables (N)	Mean± SD	p value*	
Gender			
Male (357)	9.9± 7.2	0.003	
Female (475)	11.5± 5.8		
Grades		Comparisons	p value**
1st (173)	6.7± 6.6	1st vs 2nd	< 0.001
2nd (86)	10.4± 5.6	1st vs 3rd	< 0.001
3rd (192)	10.9± 5.8	1st vs 4th	< 0.001
4th (236)	12.0± 5.6	1st vs 5th	< 0.001

5th (145)	14.0± 6.2	2nd vs 3rd	NS
		2nd vs 4th	NS
		2nd vs 5th	< 0.001
		3rd vs 4th	NS
		3rd vs 5th	< 0.001
		4th vs 5th	0.046
Computer skills			
Basic (339)	3.1± 3.3	Basic vs intermediate	< 0.001
Intermediate (394)	9.2± 6.2	Basic vs advanced	< 0.001
Advanced (99)	13.8± 6.1	Intermediate vs advanced	< 0.001
TB-learning experience			
No experience (464)	8.4± 6.1	No experience vs fair	< 0.001
Fair (305)	13.5± 5.1	No experience vs experienced	< 0.001
Experienced (63)	16.2± 6.0	Fair vs experienced	0.018

* Significant at $p < 0.05$ by Mann-Whitney test

** Significant at $p < 0.05$ by Kruskal-Wallis test followed by Dunn-Bonferroni *post hoc*

Figure 1. Percentages of positive and negative responses to each question in part I (A) and part II (B). For part I, the most positive response (64%) was associated with the question about the importance of computer technology in modern education. Meanwhile, the most negative responses were associated with whether TB-learning achieved the desired goals (19%) and whether TB-learning can substitute for conventional learning (20%). For part II, about 79% of respondents thought that online lectures need further improvements and only 17% considered that TB-learning courses are more useful than those delivered in a traditional classroom setting.

A

B