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Sri Lankan dental students' perspective on the effectiveness of e-learning

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Abstract

Introduction: E-learning resulted in a revolution in dental education with continuous educational experiences. General objective of this study was to assess the perspective of undergraduate dental students on effectiveness of e-learning in the Bachelor of Dental Surgery (BDS) programme. Specific objectives were to identify students' opinion on the factors that promote e-learning, awareness on the effectiveness of using different platforms and social media, barriers imposed and suggestions for the improvement of e-learning in the BDS programme.

Methods: This was a cross sectional descriptive study among undergraduate dental students of the Faculty of Dental Sciences, University of Peradeniya, Sri Lanka using a self-administered pre-tested questionnaire administered via a web-based survey form. Frequencies and percentages were obtained for categorical data and Chi-square test was used to determine the association between variables.

Results: The majority received the e-learning experience well. Fifty-four percent of the participants felt it was better compared to traditional face-to-face learning and the difference between the semesters (p=0.000) and genders was statistically significant (p=0.000). Difference in overall satisfaction on e-learning material across the different semesters was statistically significant. Students felt that e-learning should be used as a supplementary tool mainly by means of procedural videos during delivery of the skill component. Fifty percent participants felt that conducting assessments online is fair for all the students.

Conclusion: A positive learning experience was achieved through the e-learning modalities in comparison to traditional face-to-face learning though in terms of skills training, e-learning modalities should only be considered as a supplementary tool.

Keywords: *E-Learning, Perspective, Dental Undergraduates, Dental Education*

Practice Highlights
- Majority felt e-learning was better compared to traditional face-to-face learning.
- Majority were satisfied with interactions with teachers and teacher responses to clarifications.
- Students felt that e-learning used as a supplementary tool during delivery of the skill component.

I. INTRODUCTION

E-learning has resulted in a revolutionising dental education to an extent that more interactive and intuitive e-learning options have evolved which provide students with an enjoyable and meaningful continuum to their educational experience. During the current COVID-19 pandemic electronic learning tools have been invaluable in the delivery of knowledge in many higher education institutions (Li & Lalani, 2020). One of the great advantages of e-learning is the possibility of transferring knowledge and skills to a large number of recipients irrespective of the time of delivery of knowledge (Asiry, 2017). In addition, students can repeatedly peruse the material and follow it in their own pace at a relatively

low cost. This is considered an excellent method of overcoming certain difficulties faced with the traditional system of teaching such as the lack of space especially within the lecture halls and a shortage of human resources (Asiry, 2017). However, socio-economic factors play an important role in deciding the type of teaching. Students in the developed countries prefer e-learning modalities while students in the developing countries prefer it as a supplementary method (Schlenz et al., 2020). A study by Asiry (2017) identified e-learning as a helpful supplementary learning method among Saudi Arabian dental students rather than a replacement for traditional teaching methods. According to authors' experience, though there was much resistance in adopting to e-learning at its infancy, it has now been universally accepted as a learning modality not only by teachers but also by the students. Many are of the view that assimilation of knowledge could be best achieved purely through e-learning modalities where as it should be supplementary in nature in skills acquisition. The popularity of books and hard copies of journals have seen a steady decline due to the availability of e-learning resources and even publishers have realised this trend and supply both hard and electronic versions of their publications which in future may progressively be replaced by electronic educational materials.

The success of e-learning is dependent on a multitude of factors. Computer literacy, availability of appropriate technology, accessibility and having a good high bandwidth internet connection are some of the key factors (Asiry, 2017; Linjawi & Alfadda, 2018). According to a study by Gunawardane and Wijekoon (2017), it was revealed that dental students in the Faculty of Dental Sciences, University of Peradeniya, Sri Lanka had adequate computer literacy and facilities. Although Linjawi and Alfadda (2018) identified that the perceived impact of e-learning and readiness for e-learning though popular and satisfactory among Saudi Arabian dental students, declined as they proceeded to higher semesters. Imparting the skills component has been identified as a major challenge in using e-learning and students were in need of more support in the skills domain (Linjawi & Alfadda, 2018). Students have been shown to have better skills and motivation for use of online tools for personal or non-educational purposes than for learning purposes. Thus, this should be carefully considered when developing a successful strategy to motivate them for e-learning (Linjawi & Alfadda, 2018). Apart from the above mentioned factors, student characteristics, cognitive factors (performance expectations) and the social environment (learning climate) are considered as some predictors of the perceived satisfaction among students (Venkatesh et al., 2019). Most of the students prefer a combined approach comprising traditional and e-learning methods than relying on e-learning methods

alone. Some of the preferred methods of delivery of e-learning resources for pre-clinical dental undergraduates were online flash lectures and procedural videos (Asiry, 2017). Video demonstrations enabled students to reflect on their predominant learning approaches, which emphasise self-directed learning and avoid surface learning techniques (Chonkar et al., 2019). Some dental schools in the developed countries have introduced tools such as Technology Enhanced Learning (TEL) in both pre-clinical and clinical courses with the development of innovative learning platforms and they further assess and monitor student performance in relation to the new approach (Wong et al., 2020). Further, Faculty of Dentistry, National University of Singapore has implemented a multi-stage framework for the academic staff to grasp technology in various aspects such as reflecting teaching practice, designing new technology options and identifying learner impact with changes on teaching methods.

However, not everyone is in agreement with the benefits of e-learning. University administrators and experts in information technology working in universities have varying opinion (ranging from majority of teaching on traditional classroom mode to predominant e-learning mode) regarding the need of administrational change created by e-learning, generation of resources, impact on enrolment, responsibility for course design and content and the impact on the mission of the university. However, there is a general agreement on challenges such as the requirement of resources and cost of maintenance, need for motivating the teachers to keep abreast with the latest technology and the necessity for cooperation to improve e-learning (Hillenburg et al., 2006).

The COVID-19 pandemic has made it necessary to impart changers in the modalities of education all over the world. Since schools and universities have been closed to prevent the spread of infection, conducting e-learning sessions has become the prime mode of teaching. The situation in Sri Lanka was without exception. Most programmes including the Bachelor of Dental Surgery had to comply with this requirement in order to provide the students a continuous educational experience during the pandemic situation. E-learning has been used in a very primitive level in the Faculty of Dental Sciences, University of Peradeniya for a long time but had not been utilised to its full potential. As dentistry is mostly a skill based professional degree programme, delivering course content online was a challenge. In addition, resistance to change was evident among the staff due to the fact that they were comfortable with the traditional time tested methods. However, with the new norms, e-learning platforms such as Zoom,

Google Meet and WhatsApp discussions were used at the Faculty of Dental Sciences for the learning along with narrated PowerPoint presentations, video demonstrations and online quizzes uploaded onto the existing e-learning platform Dent Moodle. Due to this novel experience, it was considered important to analyse the students' opinion on e-learning, the difficulties faced by them and expectations to improve e-learning in the field of dentistry. Further, it would be beneficial to identify barriers of e-learning when designing and revising the dental undergraduate curriculum in the future.

II. OBJECTIVES

General objective of the study was to assess the undergraduate dental students' perception on the effectiveness of e-learning utilised in the Bachelor of Dental Surgery (BDS) programme. The specific objectives were to identify students' opinion on the factors that promote e-learning, awareness on the effectiveness of using different platforms and social media, barriers imposed and suggestions for the improvement of e-learning in the BDS study programme.

III. MATERIALS AND METHODS

A cross sectional descriptive study was carried out on a sample comprising of undergraduate dental students of the Faculty of Dental Sciences, University of Peradeniya who had enrolled and followed all online lectures and assignments based on the content taught via e-learning in the first, third, fifth and seventh semesters. A self-administered and pre-tested (25 students representing all batches for the pilot and their responses were excluded from the study sample) questionnaire was administered via a web-based survey form. A covering letter, information sheet and consent form were also annexed to this form. Those respondents who gave the informed consent were able to fill the questionnaire. The survey link was disseminated among the dental students via the email by the faculty administration unit. The questionnaire used in this study comprised of 23 close-ended questions which consisted of demographic data and specific questions on awareness, attitude and practice of e-learning. Examples of e-learning platform stated in the questionnaire were live Zoom presentations, Google Meet, Power Point presentations with voice narrations and supplementary material such as web links, video demonstrations and YouTube and other video links.

Confidentiality and anonymity of the data provided were assured by keeping the questionnaire anonymous. No identification details were included in the questionnaire. Data management and statistical analysis was performed using the statistical software SPSS version 21.0. Frequencies and percentages were obtained for categorical data and Chi-square test was used to determine the association between variables. Ethical clearance was obtained from the Ethics Review Committee of the Faculty of Dental Sciences, University of Peradeniya (ERC/ FDS/UOP/I/2020/21).

IV. RESULTS

The response rate was 82% (250 participants out of 305 of all undergraduates). The sample comprised 19% from the first semester, nearly 25% from the third semester, 26% from the fifth semester and nearly 30% from the seventh semesters of the Bachelor of Dental Surgery (BDS) programme. Seventy-two percent (72%) were females. Approximately 41% claimed that they have either very good or excellent literacy on information technology (IT). Fifty-four percent of the respondents claimed that their English language literacy is very good or excellent. A majority of the population accessed e-learning content using their mobile devices. Half of the sample had experienced some kind of interruptions during e-learning.

A. Satisfaction on E-learning

Seventy-one percent (71%) responded that they were either satisfied or highly satisfied about e-learning materials they received. More than one third of the respondents (39%) felt encouraged to collaborate and interact with their teachers during e-learning time compared to the in-class teaching sessions. A similar percentage of respondents felt that they were more encouraged to work on course materials compared to the traditional learning sessions received at the university. Around 74% of the students felt that the teachers were friendly during e-learning sessions. Moreover, 62% of them were either satisfied or highly satisfied with the provision to ask questions during e-learning sessions. Sixty percent (60%) of respondents was satisfied or highly satisfied with the answers received for the clarifications they requested. Seventy percent (70%) of the students claimed that the interactions between the lecturers and students during question and answer sessions, case scenarios and case discussions were essential for the success of e-learning experience. Fifty-five percent (55%) of them were satisfied with the interactions they experienced during e-learning sessions in their study period. Interestingly, more than one third of the respondents were of the opinion that online lectures were more effective than traditional live lectures. Moreover, 54% of the sample felt that the overall e-learning experiences was better than the traditional learning opportunities they received in the university and the possibility of following the coursework at their own pace (14.8%) was chosen as the main reason for this response.

Females had better overall e-learning experiences than the learning opportunities they received at the university compared to male students and this difference was statistically significant (p=0.000) (Table 1).

Surprisingly, only 1% of the respondents had identified social media as a positive influence on e-learning.

Table 1 describes participants' response to the questionnaire according to their gender.

Variable	Females (%)	Males (%)	P value
Level of IT literacy	38	48	**0.045**
overall satisfaction on the e-learning materials received	71.7	85.5	0.051
felt encouraged to work on course material compared to the learning sessions received at the university	48.3	44.9	0.302
feel the teachers were friendly during the e-learning sessions	73.9	75.4	0.924
think the interactions between the lecturer and student are essential to e-learning	74.4	59.4	0.170
satisfaction on the student-teacher interaction experienced during the e-learning sessions	58.3	47.8	0.687
think the online lectures are effective than traditional/live lectures	38.3	40.6	0.256
think over all e-learning experiences are better than the learning opportunities you received at the university	56.1	49.3	**0.000**
The best way you prefer to receive a lecture through e-learning			
PowerPoint presentation with the narration recording	68.3	69.6	0.936
PowerPoint video presentation	21.1	21.7	
Zoom live presentation	10	8.7	
think the e-learning could be useful in improving the knowledge on the course content	83.9	85.5	0.255
overall satisfied with e-learning experience	67.8	62.3	0.525
Think conducting assessments through online will be fair for all students			
Yes	33.9	24.6	0.387
No	33.9	31.9	

Table 1. Comparison of participants' response according to their gender (in percentages)

B. Preference on Methods of E-learning

Sixty-four percent (64%) of the participants were familiar with Zoom as an e-learning platform. Majority of the students preferred PowerPoint presentations with narrations (68%) to receive lectures. In addition, 69% felt that e-learning materials had helped them to improve their knowledge on the course content specified in the Intended Learning Outcomes (ILOs). Around 34% had identified video demonstrations as an important tool in imparting skills training to achieve the course ILOs. Over 70% rated it as highly useful when students' opinion is taken in consideration in improving knowledge on the course content.

Sixty-four percent (64%) felt that that e-learning material should be used as supplementary materials for in-class learning within the skills domain. The e-learning materials considered appropriate were video demonstrations, procedural steps described in text documents, YouTube links and case discussions. Majority of the courses in the first semester (Anatomy, Dental Anatomy and Physiology related), third semester (Tooth morphology and occlusion, Human Diseases, Dental Biomaterials), fifth semester (Operative Dentistry, Population Oral Health, Clinical and Diagnostic Oral Sciences [CDOS1] and Child and Adolescent Oral Health [CAOH1]) and seventh semester (Adult Oral Health, CDOS2 and CAOH2) were rated as suitable for e-learning activities.

C. Opinion on Assessment via E-Learning Platforms

The Multiple Choice Questions (MCQ) and Short Answer Questions (SAQ) were the more common forms of assessments provided to the participants. However, some students (9%) had experience with essays too. These assessments were formative in nature whereby the questions were posted after each learning session in order to assess the effectiveness of the learning process. These questions were marked by the teachers or self-marked by the students. Sixty-nine percent (69%) felt that conducting assessments online is fair.

D. Opinion on Barriers Identified in E-Learning

Though the majority of first semester students had identified inadequate opportunities to work with other batch mates as a stumbling block, the majority of the seventh semester had identified technical difficulties in accessing the e-learning resources as the major barrier in e-learning. However, there was no significant difference

in the responses between the genders and the semester of study of the student.

E. Suggestions to Improve E-Learning

When the students were requested to suggest ways to use the e-learning to improve the required skills, approximately half (52%) of the respondents preferred video demonstrations on clinical and lab procedures. Furthermore, multiple choice questions, use of charts to explain presentations, discussion forums, quizzes, assignments, web links and supplementary reading material were other ways of improving the learning experience as suggested by the participants. However, 3% of the students had clearly mentioned that e-learning could not be used to improve the required skills in dentistry.

There were multiple suggestions by the majority to improve the overall effectiveness of their e-learning experience. Some of the suggestions were uploading of lectures coupled with assignments, video demonstrations especially for practical scenarios, lectures followed by discussions and lectures on Zoom followed by case discussions. However, the statistical significance could not be assessed between genders or semesters as the number of responses for each option was small.

F. Analysis of Results According to the Respondents' Current Semester

When the results were assessed according to the current semester, a majority of the first, third and seventh semesters students preferred video demonstrations for e-learning sessions. However, a majority of the fifth semester students preferred a combination of video demonstrations and a text document describing procedural steps or video demonstrations combined with YouTube links and discussion forums. Respondents from first semester had the highest overall satisfaction on e-learning materials they received and the difference between the semesters was statistically significant. (p=0.002). Over two-thirds of the seventh semester students (being the students who were exposed to conventional classroom learning experience for more than three years) confirmed that their overall e-learning experiences were better than the traditional classroom learning opportunities they received at the university and the difference was statistically significant (p=0.000) (Table 2). Further, students' rating of e-learning materials received from teachers (p=0.002) (Figure 1) and encouragement to work on course material compared to the learning sessions received at the university (p=0.015) (Figure 2) were statistically significant when the semester of study were considered.

Table 2 describes participants' response to the questionnaire according to their semester of study.

Variable	First (%)	Third (%)	Fifth (%)	Seventh (%)	P value
Level of your IT literacy	50	33.3	33.8	44.6	0.162
overall satisfaction on the e-learning materials received	91.7	58.1	70.8	70.3	**0.002**
felt encouraged to work on course material compared to the learning sessions received at the university	52.1	32.3	49.2	55.4	**0.015**
feel the teachers were friendly during the e-learning sessions	93.8	74.2	76.9	59.5	**0.001**
think the interactions between the lecturer and student are essential to e-learning	79.2	70.1	76.9	58.1	0.191
satisfaction on the student-teacher interaction experienced during the e-learning sessions	72.9	48.4	58.5	47.3	**0.001**
think the online lectures are effective than traditional/live lectures	33.33	33.9	32.3	52.8	**0.025**
think over all e-learning experiences are better than the learning opportunities you received at the university	52.1	38.7	52.3	70.7	**0.000**
the best way you prefer to receive a lecture through e-learning					
PowerPoint presentation with the narration recording	47.9	69.3	84.6	67.6	
PowerPoint video presentation	41.7	22.6	6.2	20.3	**0.000**
Zoom live presentation	10.4	6.5	9.2	12.2	
think the e-learning could be useful in improving the knowledge on the course content	89.6	75.8	83.1	89.2	0.523
overall satisfied with e-learning experience	81.2	54.8	63.1	68.9	**0.039**
think conducting assessments through online will be fair for all students					
Yes	52.1	12.9	33.8	31.1	**0.000**
No	10.4	46.8	35.4	35.1	

felt the encouragement to collaborate and interact with your teachers during e-learning compared to the sessions you receive in-class teaching	58.3	27.4	40	36.5	**0.007**
had adequate facility to ask questions and clarify doubts during e-learning sessions	93.7	43.5	72.3	50	**0.000**
experience in receiving answers from the teacher to the questions/clarifications you wanted were satisfactory	87.5	50	73.8	47.3	**0.000**
think that the e-learning materials have helped to improve your knowledge on the course content as required in ILOs	81.25	62.9	64.6	73.6	0.115

Table 2. Variations of participants' response according to their semester of study (in percentages)

Figure 1 shows students' rating of e-learning materials received from teachers according to their semester of study.
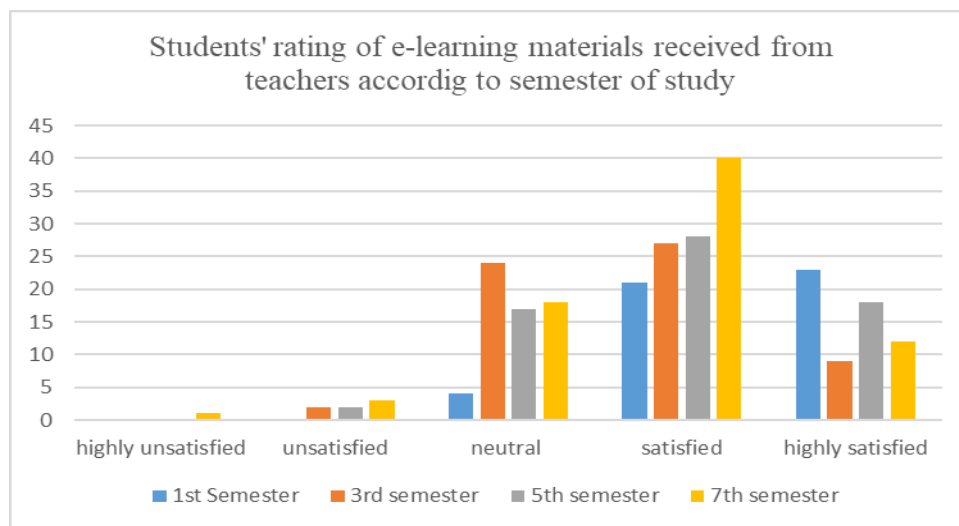

Figure 1. Students' rating of e-learning materials received from teachers according to their semester of study

Figure 2 shows students' feeling of encouragement to work on course material compared to conventional learning sessions received at the university.
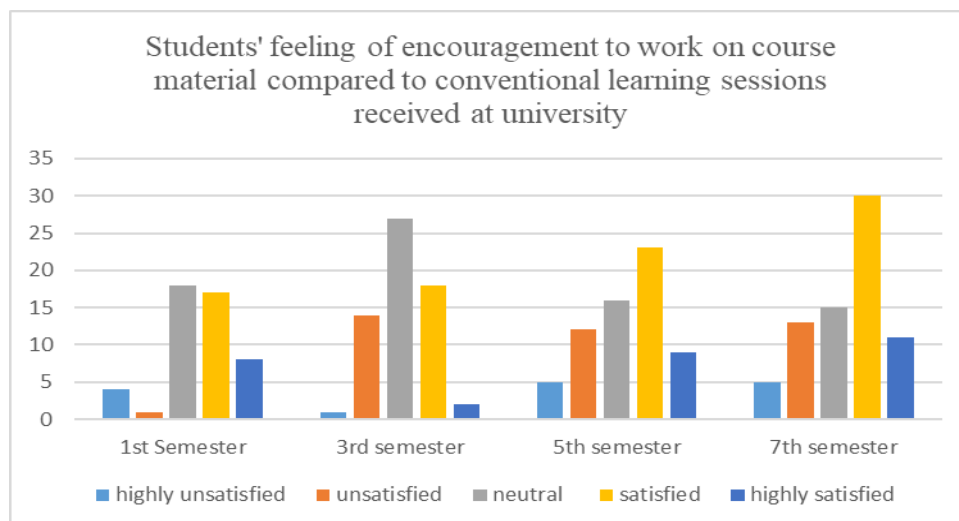

Figure 2. Students' feeling of encouragement to work on course material compared to conventional learning sessions received at the university according to their semester of study

When the results were analysed according to theory based courses (Anatomy, Oral Biology, Human Diseases, Tooth morphology and Occlusion, Dental Biomaterials) against practical, lab based and clinical training courses (Adult Oral Health, Population Oral Health, Clinical and Diagnostic Oral Sciences, Child and Adolescent Oral Health), the participants' overall e-learning experience in theory based courses was significantly higher than practical and clinical courses (p= 0.03).

All data are available at https://figshare.com/s/c6c7b8f1d5cfd0076808.

V. DISCUSSION

E-learning is a broad term which encompasses the use of software applications to support learning, whether online or offline (Piccoli et al., 2001). The efficacy of an e-learning experience is dependent on many factors such as availability of devices, access to internet, knowledge on IT and uninterrupted internet connectivity (Asiry, 2017; Linjawi & Alfadda, 2018).

In the present study, half of the sample experienced some interruption during the e-learning sessions. It has been demonstrated in previous studies that students generally have a positive outlook to e-learning in spite of technical problems and related stresses (Brumini et al., 2014). Other studies have also highlighted positive experiences in isolated dental specialties (Bains et al., 2011; Gonzalez & Gadbury-Amyot, 2016; Qi et al., 2013; Reissmann et al., 2015). Our results revealed that students had a better learning experience with e-learning in comparison to traditional methods which was compatible with the findings of similar studies (Turkyilmaz et al., 2019). A study in Germany involving undergraduate dental students stated that participation in online learning was higher compared to "face-to-face" courses which was similar to the findings of the present study (Schlenz et al., 2020). Reasons for popularity of e-learning material over face-to-face learning are that it not only provides flexibility in the learning process (p=0.003) but also saves time (p = 0.012) (Anwar et al., 2021).

When the students' perception on e-learning resources were analysed, males showed better IT literacy in comparison to female students. Even though the female students were not as confident as male students, a majority of them expressed that the overall e-learning experience was better than the conventional learning. These findings endorse the observations of Linjawi and Alfadda (2018) where the students claimed that they had better skills and motivation for e-learning than conventional learning activities. The identification of social media platforms for e-learning opportunities by a very few students in our study corroborate the fact that formal modalities of delivering e-learning resources should be implemented rather than relying on generic platforms.

Participants' overall e-learning experience in theory based courses were significantly higher than practical and clinical courses due to the need of hands on experience, simulator training and working with patients for the practical and clinical courses than listening, reading and writing practice. This fact should be carefully considered when developing and planning the modes of content delivery as the knowledge and skills domains should be separately considered. More theory could be delivered through e-learning modalities and this time saved could be utilised for the face to face delivery of practical and clinical procedural teaching in predominantly skills based courses such as the Bachelor of Dental Surgery. However, the findings contradict the previous belief of the faculty that e-learning should only be used as a supplementary tool. There is a possibility to incorporate classroom and e-learning as a blended learning experience when imparting theory components in the future to save time, improve efficient use of limited infrastructure and to focus more on much needed skill development in dentistry. Incorporation of e-learning facilities to the maximum possible level should also be considered in future planning of the state universities in the delivery of undergraduate education in countries such as in Sri Lanka to enhance the quality of learning using the minimal physical and human resources available. Reports from experience in other countries highlight that e-learning processes are also cost effective, due to the availability of low cost or free online tools and platforms which can be used by teachers with a sound background of pedagogical knowledge (Goh, 2018).

First semester had the highest overall satisfaction on e-learning. This group consisted of students who hardly had any noteworthy face-to-face learning experience in the Faculty of Dental Sciences due to the abrupt closure during pandemic situation. Therefore, it seems that they could not effectively compare the two learning methods. Though less than first semester, more than 50% of the seventh semester students had a positive attitude towards e-learning experience. Our finding is in agreement with the findings of a previous study where it was shown that the perceived impact of e-learning and readiness for e-learning became less acceptable as students became mature (Linjawi & Alfadda, 2018).

Positive feedback regarding e-learning experience showed statistically significant differences between students of different semesters in relation to overall satisfaction on the e-learning materials received; encouragement to work on course materials; feeling that the teachers were friendly during the e-learning sessions; satisfaction on the student-teacher interaction during e-learning sessions. These findings should be considered when modes of learning for different components are planned by the Faculty of Dental Sciences during future revisions to the curriculum. Similarly, a recent report on undergraduate dental education during the COVID-19 pandemic has described that e-learning has been

appreciated not only by students and teachers, but also in relation to the teacher-student interaction (Bennardo et al., 2020).

A majority of the students felt that the best way to receive the theory component was through PowerPoint presentation with voice narrations. This was statistically significant when compared among different semesters. This is in contrast with the preferred e-learning method among the Saudi Arabian dental students whereby online flash lectures were the most preferred method (Asiry, 2017).

Similar to our findings, a study on health care students belonging to 11 countries among the developed and developing nations also identified that 60% agreed that clinical and practical skills are best learned in clinics and laboratories (Abbasi et al., 2020). Another study involving over 3000 medical students of all years from over 13 schools in Libya has revealed only 21% agreed that e-learning could be used for clinical aspects, as compared with 55% who disagreed with this statement and 24% who were neutral (Alsoufi et al., 2020). The students 'most preferred mode to learn skills as prescribed in the ILOs was through the use of procedural videos. A previous study carried out in the same institute to investigate the efficacy of procedural video versus live demonstrations revealed that that there was no appreciable difference in the development of skills in dental laboratory technology procedures (Thilakumara et al., 2018). This outcome could be applied to our findings that e-learning sessions, if followed by discussion forums with the teachers, as suggested by the participants would dramatically improve the e-learning experience.

E-learning with its virtual learning environment also requires different skills and a positive attitude from instructors. The positive attitude of the instructors towards technology, the interactive teaching style, and control over the technology were found to have an important influence on students' reactions to the learning environment (Piccoli et al., 2001). This highlights the importance of professional development in two main aspects; technical and e-pedagogical areas (Conole & Oliver, 2002). The significance of institutional support should be highlighted. Therefore, the need of training for the teachers in the use of efficient methods for e-learning is emphasised. Furthermore, the faculty needs to have a long-term plan to encourage learning facilities through the use of different platforms, use of web links and production of supplementary video for demonstrations in order to encourage students towards a lifelong learning experience. Investment in more user-friendly and versatile software and resources to improve e-learning activities should be prioritised in order to make this

endeavour more effective, interactive and receptive to the end users.

A. Limitations of the Study

Our study was performed in a single country and in a single institution as the country has only one dental school. Therefore, the results may not be generalised to other countries and to the region. The results must be validated through further multi-centre studies in order to obtain an overall opinion. Multi-national studies would provide a better understanding on how e-learning could replace the bulk of conventional dental undergraduate clinical learning and provide cost effective solutions for the developing countries with limited physical and human resources to avoid disruption of clinical training during difficult times such as the present COVID-19 pandemic. Another limitation is the cross-sectional nature of the study design, which limited our ability to identify causal associations.

VI. CONCLUSION

A positive learning experience was achieved through the e-learning modalities by the undergraduate dental students in comparison to traditional face-to-face learning. In terms of skills training, e-learning should only be considered as a supplementary tool. These findings will be useful when designing the study courses as a major part of theory component via e-learning mode and skill component with combined e-learning and conventional modes in the future.

We recommend adapting interactive e-learning platforms by using highly sophisticated technologies along with virtual clinical experience with combined clinical scenarios and assessments based on discussions of patient cases. Cost-effective solutions are needed to reduce disruption of undergraduate dental education especially in developing countries in the region like Sri Lanka and there should be new collective effort by the countries in the South Asian region in planning and sharing less expensive e-learning solutions in order to overcome financial issues. Such measures may vary from learning theory and virtual clinical and lab-based experience, followed by limited hands-on experience on live patients in a safe environment during difficult times of this nature.

Notes on Contributors

Principal and corresponding author (Rasika Jayasinghe) conceptualised the research and edited the initial draft and wrote the results after analysis. She also did the final approval of the version to be published and agreed to be accountable for all aspects of the work.

Manjula Attygalla edited the initial draft of the manuscript and supported in modification of the questionnaire. He also did the final approval of the version to be published and agreed to be accountable for all aspects of the work.

Manil Fonseka supported planning of the study, edited the research proposal and manuscript. He also did final editing and approval of the version to be published and agreed to be accountable for all aspects of the work.

Dhanushka Leuke Bandara supported planning of the study, designed the Google form, carried out the survey and entered the data in addition to editing of the manuscript. She also did final approval of the version to be published and agreed to be accountable for all aspects of the work.

Gishan Edirisinghe carried out the literature survey and did the final approval of the version to be published and agreed to be accountable for all aspects of the work.

Ruwan Jayasinghe supported planning of the study, prepared the initial draft of the research proposal and edited the final draft of the manuscript. He did the final approval of the version to be published and agreed to be accountable for all aspects of the work.

Indika Thilakumara supported planning of the study, edited the first draft and wrote the discussion. She did the final approval of the version to be published and agreed to be accountable for all aspects of the work.

Ethical Approval
Ethical clearance has been granted by Ethics Review Committee, Faculty of Dental Sciences, University of Peradeniya. (ERC/FDS/UOP/I/2020/21).

Data Availability
All data are available at

https://figshare.com/s/c6c7b8f1d5cfd0076808 and can be accessed on request and approval from the corresponding author.

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Declaration of Interest
Authors declare that they do not have possible conflicts of interest, including financial, consultant, institutional and other relationships that might lead to bias or a conflict of interest.

References

Abbasi, M. S., Ahmed, N., Sajjad, B., Alshahrani, A., Saeed, S., Sarfaraz, S., Alhamdan, R. S., Vohra, F., & Abduljabbar, T.E. (2020). E-Learning perception and satisfaction among health sciences students amid the COVID-19 pandemic. *Work, 67*(3), 549-556. https://doi.org/10.3233/WOR-203308

Alsoufi, A., Alsuyihili, A., Msherghi, A., Elhadi, A., Atiyah, H., Ashini, A., Ashwieb, A., Ghula, M., Hasan, H. B., Abudabuos, S., Alameen, H., Abokhdhir, T., Anaiba, M., Nagib, T., Shuwayyah, A., Benothman, R., Arrefae, G., Alkhwayildi, A., Alhadi, A., … Elhadi, M. (2020). Impact of the COVID-19 pandemic on medical education: Medical students' knowledge, attitudes, and practices regarding electronic learning. *PLOS ONE, 15*(11), e0242905. https://doi.org/10.1371/journal.pone.0242905

Anwar, A., Mansoor, H., Faisal, D., & Khan, H. S. (2021). E-learning amid the COVID-19 lockdown: Standpoint of medical and dental undergraduates. *Pakistani Journal of Medical Sciences, 37*(1), 217-222. https://doi.org/10.12669/pjms.37.1.3124

Asiry, M. A. (2017). Dental students' perceptions of an online learning. *The Saudi Dental Journal, 29*(4), 167–170. https://doi.org/10.1016/j.sdentj.2017.03.005

Bains, M., Reynolds, P. A., McDonald, F., & Sherriff, M. (2011). Effectiveness and acceptability of face-to-face, blended and e-learning: A randomised trial of orthodontic undergraduates. *European Journal of Dental Education, 15*(2), 110–117. https://doi.org/10.1111/j.1600-0579.2010.00651.x

Bennardo, F., Buffone, C., Fortunato, L., & Giudice, A. (2020). COVID-19 is a challenge for dental education—A commentary. *European Journal of Dental Education, 24*(4), 822-824. https://doi.org/10.1111/eje.12555

Brumini, G., Špalj, S., Mavrinac, M., Biočina-Lukenda, D., Strujić, M., & Brumini, M. (2014). Attitudes towards e-learning amongst dental students at the universities in Croatia. *European Journal of Dental Education, 18*(1), 15-23. https://doi.org/10.1111/eje.12068

Chonkar, S. P., Qi, H. L. C., Ha, T. C., Lim, M., Ng, M. J., & Tan, K. H. (2019). Can digital media affect the learning approach of medical students? *The Asia Pacific Scholar, 4*(1), 13- 23. https://doi.org/10.29060/TAPS.2019-4-1/OA1058

Conole, G. C., & Oliver, M. (2002). Embedding theory into learning technology practice with toolkits. *Journal of Interactive Media in Education* (8), 2- 3. https://doi.org/10.5334/2002-8

Goh, P. S. (2018). eLearning in medical education – Costs and value add. *The Asia Pacific Scholar, 3*(2), 58- 60. https://doi.org/10.29060/TAPS.2018-3-2/PV1073

Gonzalez, S. M., & Gadbury-Amyot, C. C. (2016). Using Twitter for teaching and learning in an oral and maxillofacial radiology course. *Journal Dental Education, 80*(2), 149–155. https://doi.org/10.1002/j.0022-0337.2016.80.2.tb06070.x

Gunawardane, S., & Wijekoon, P. (2017). Changes in perceived computer use and knowledge in Sri Lankan dental students in the last ten years. *Scholars Journal of Dental Sciences, 4*(5), 216-219.

Hillenburg, K. L., Cederberg, R. A., Gray, S. A., Hurst, C. L., Johnson, G. K., & Potter, B. J. (2006). E-learning and the future of dental education: Opinions of administrators and information technology specialists. *European Journal of Dental Education, 10*, 169–177. https://doi.org/10.1111/j.1600-0579.2006.00413.x

Li, C., & Lalani, F. (2020). The COVID-19 pandemic has changed education forever. This is how. *World Economic Forum*. https://www.weforum.org/agenda/2020/04/coronavirus-

education-global-covid19-online-digital-learning

Linjawi, A. I., & Alfadda, L. S. (2018). Students' perception, attitudes, and readiness toward online learning in dental education in Saudi Arabia: A cohort study. *Advances in Medical Education and Practice, 9*, 855–863. https://doi.org/10.2147/AMEP.S175395

Piccoli, G., Ahmed, R., & Ives, B. (2001). Web-based virtual learning environments: A research framework and a preliminary assessment of effectiveness in basic IT skills training. *MIS Quarterly, 25*(4), 401-426. https://doi.org/10.2307/3250989

Qi, S., Yan, Y., Li, R., & Hu, J. (2013). The impact of active versus passive use of 3D technology: A study of dental students at Wuhan University, China. *Journal of Dental Education, 77(11)*, 1536–1542.

Reissmann, D. R., Sierwald, I., Berger, F., & Heydecke, G. (2015). A model of blended learning in a preclinical course in prosthetic dentistry. *Journal of Dental Education, 79*(2), 157–165 https://doi.org/10.1002/j.0022-0337.2015.79.2.tb05870.x

Schlenz, M. A., Michel, K., Wegner, K., Schmidt, A., Rehmann, P., & Wöstmann, B. (2020). Undergraduate dental students' perspective on the implementation of digital dentistry in the preclinical curriculum: A questionnaire survey. *BMC Oral Health*, *20*, 78. https://doi.org/10.1186/s12903-020-01071-0

Thilakumara, I. P., Jayasinghe, R. M., Rasnayaka, S. K., Jayasinghe, V. P., & Abeysundara, S. (2018). Effectiveness of procedural video verses live demonstrations in teaching laboratory techniques to dental students. *Journal of Dental Education, 82*(8), 898-904.
https://doi.org/ 10.21815/JDE.018.086

Turkyilmaz, I., Hariri, N. H., & Jahangiri, L. (2019). Student's perception of the impact of e-learning on dental education. *Journal of Contemporary Dental Practice*, *20*(5), 616-621.

Venkatesh, S., Rao, Y. K., Nagaraja, H., Woolley, T., Alele, F. O., Bunmi, S., & Malau-Aduli, B. S. (2019). Factors influencing medical students' experiences and satisfaction with blended integrated e-learning. *Medical Principles and Practice, 29*, 296-402. https://doi.org/10.1159/000505210

Wong, M. L., Lee, T. W. O., Allen, P. F., & Foong, K. W. C. (2020). Dental education in Singapore: A journey of 90 years and beyond. *The Asia Pacific Scholar, 5*(1), 3- 7. https://doi.org/10.29060/TAPS.2020-5-1/GP1086

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