STUDY PROTOCOL

Pre-clinical undergraduate students' perspectives on the adoption of virtual and augmented reality to their dental learning experience: A one-group pre- and post-test design protocol [version 1; peer review: 1 approved, 1 approved with reservations]

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Abstract

Background: We live in a time where traditional education has rapidly incorporated online modalities due to the recent SARS-CoV-2 (COVID-19) safety measures such as social distancing. Regardless of these challenges, health education constantly strives to implement the best technologies available for an effective student deep learning outcome. Virtual (VR) and augmented reality (AR) in the dental pre-clinical stage may help stimulate students to better understand the foundation material prescribed in the curriculum. Most visual material available for students is still mainly based on 2D graphics. Thus, this study will attempt to evaluate the students' perceptions about implementing VR/AR technologies in the learning setting.

Methods: A single-group pretest-posttest design will be implemented where students will be exposed to VR/AR and fill out two questionnaires, one before and one after the exposure.

Conclusions: This project is intended to start once the institutional ethical approval is obtained. It is expected that the analysis from the current project will provide recommendations to improve the students' academic curriculum pre-clinical experience. The recommendations will be provided in the form of at least three

Open Peer Review

Approval Status ? ✓

	1	2
version 2 (revision) 05 Jan 2023		
version 1 15 Jun 2021	 view	 view
1. Anand Marya , University of Puthisastra, Phnom Penh, Cambodia Saveetha University, Chennai, India 2. Kenneth Y. T. Lim , National Institute of Education, Singapore, Singapore		
Any reports and responses or comments on the article can be found at the end of the article.		

scientific publications, with one publication for each subject area intended to be evaluated (i.e., head and neck anatomy, dental anatomy, and removable prosthodontics).

Keywords

Augmented Reality, Curriculum, Dental Students, Health Education, Immersion, Learning, Perception, Virtual Reality.

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Author roles: **Afrashtehfar KI:** Conceptualization, Investigation, Methodology, Project Administration, Resources, Supervision, Writing – Original Draft Preparation, Writing – Review & Editing; **Yang JW:** Validation, Visualization, Writing – Review & Editing; **Al-Sammarraie A:** Formal Analysis, Writing – Review & Editing; **Chen H:** Validation, Visualization, Writing – Review & Editing; **Saeed MH:** Funding Acquisition, Project Administration, Resources, Visualization, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: The author(s) declared that no grants were involved in supporting this work.

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Introduction

Digital technology has been adopted rapidly in student education. Virtual reality (VR) and augmented reality (AR) tools seem to result in an intense immersion¹. The spatial perception about 3D objects may reproduce successful representation in a VR environment. However, to date, dental education is primarily aided by 2D image sources. It is believed that a VR teaching environment may deepen the understanding of dental anatomy². In fact, a teaching environment with spatial representations improves the outcomes compared with 2D graphics, by keeping students motivated and providing them with an improved understanding^{3,4}.

The study will be conducted on United Arab Emirates (UAE) pre-clinical dental students. It is essential to evaluate the potential for adopting a VR teaching environment for UAE pre-clinical dental students when understanding and learning about each tooth's characteristics, head and neck components, as well as partial and complete removable dental prostheses. It is equally important to assess the impact of VR in these courses, as perceived by the students. Thus, we hypothesized that students who learned using the traditional 2D teaching pre-clinical content (dental anatomy, head and neck, and removable prosthodontics courses) would not perceive a significant advantage in learning while implementing a VR/AR teaching environment.

Objectives

This study aims to evaluate the dental students' perceptions of the current undergraduate dental anatomy, head and neck anatomy, and removable prosthodontics training curriculum, as well as their perspectives on the incorporation of virtual learning into the curriculum.

The research questions that the project intends to answer are as follows:

- What are the dental students' perceptions on the current undergraduate dental anatomy training?
  - What are the dental students' perceptions of the undergraduate dental anatomy training teaching during the 2020 summer session (fully online version) versus the 2021 fall session (blended learning)?
- What are the dental students' perspectives on incorporating virtual learning into the dental anatomy training curriculum?
  - What are the dental students' perspectives of the incorporation of virtual learning into the dental anatomy training curriculum after experiencing the test?
- What are the dental students' perceptions on the current undergraduate removable prosthodontics training curriculum?
  - What are the dental students' perspectives of the incorporation of virtual learning into the removable

prosthodontics training curriculum after experiencing the test?

Protocol

During the 2021–2022 academic year, we will conduct a study with undergraduate students who have previously taken the evaluated courses.

Participants

The eligible students (chosen based on the following selection criteria) will be recruited via email and will obtain their consent documents via email. Electronic signatures will be required for indicating consent to participate. The participants will be sent the link to the electronic surveys (pre- and post-test self-administered questionnaires) via email. Copies of the informed consent form and research instruments are available in *Extended data*⁵.

Inclusion criteria. Ajman University second-year undergraduate dental students who took the dental anatomy, head and neck anatomy, and removable prosthodontics courses will be eligible to participate.

Exclusion criteria. Students who have not taken the dental anatomy course in the last academic year will not be eligible to participate.

Data collection

Given the nature of the pretest-posttest design of this study, the prospective data will be collected at two moments⁶.

The first step consists of an online (host site TBD) questionnaire (see research instrument A in *Extended data*⁵) to obtain students' perceptions regarding the traditional curriculum of dental anatomy, head and neck, and removable prosthodontics courses, and to determine students' potential acceptance of virtual learning.

The VR dental learning environment (i.e., use of VR glasses running the free-trial software [Head & Neck Anatomy version 3.0, 3D Tooth Atlas version 9.0, Complete Dentures version 1.0, and Removable Partial Dentures version 1.0; eHuman Inc., Fremont, Calif., USA] from their own mobile phones) will be available to the pre-clinical students for 30 minutes each, to test the student curriculum's appropriateness.

After exposure to the VR/AR learning environment, the participants will provide feedback (see research instrument B in *Extended data*⁵). The post-test questionnaire will consist of selecting an answer for each prompt addressing their VR/AR experience and comparing it to their previous teaching methods when the courses were taken. Most answers will be categorical.

Data analysis

The results will be compiled and analyzed statistically to be presented as figures and tables.

Statistical analysis. A statistical software (IBM SPSS Statistics, Version 27.0., IBM Corp.) will be used to perform all the statistical analyses. The variables will be class, gender, age, nationality, and type of high school. The demographic characteristics will be presented in tables.

The frequency of answers for each survey question that uses the “Likert scale” will be assessed with an independent t-test. The data from each of the examined curricula will be represented as mean and standard deviations. Non-parametric tests, such as the Kruskal-Wallis test and the Mann-Whitney U test, might be used for comparing ordinal variables, domains, and items between courses and academic years. In the case of multiple comparisons between academic years, the Bonferroni correction might be applied. In the case of multiple comparisons between the teaching courses in different academic years, the Bonferroni correction could also be applied.

Sample size calculation. In terms of the sample size, 132 or more measurements/surveys are needed to have a confidence level of 95% that the real value is within $\pm 5\%$ of the measured/surveyed value since one batch population size is approximately 200.

Data safety and storage

The security and confidentiality of the participants’ identities and electronic data files will be protected, and we will keep the data in encrypted files on a password-protected laptop computer. Electronic data will also be kept, for backup purposes, on a password-protected and encrypted external hard drive, and all non-electronic data will be stored in the locked office of a researcher (KIA or MHS).

All printed material will also be stored in a locked cabinet. Since all data will be de-identified, this will be publicly available indefinitely in a secure cloud-based repository such as [Mendeley Data](#).

Formulation of the recommendations

The researchers (KIA and MHS) will describe and provide recommendations based on the current pre-clinical curriculum

for accepting or rejecting the consideration of virtual learning as a learning tool in the pre-clinical setting.

Dissemination of the results

It is expected that the analysis from the current project will provide recommendations to improve the students’ academic curriculum pre-clinical experience in the form of three publications in peer-reviewed Scopus-indexed journals^{7,8}. This will be one publication for each subject intended to be evaluated (i.e., head and neck anatomy, dental anatomy, and removable prosthodontics). Additionally, we aim to produce at least one publication at a conference proceeding. This process may take less than 12 months from the moment of the ethical approval ([Table 1](#)).

The implementation activities will include giving support to other dental institutions interested in including VR/AR resources in their curricula, such as The University of Hong Kong and The Peking University.

Ethics statement

The project involves humans considered a vulnerable population (i.e., undergraduate students) who are being exposed to a sensitive question, that is, to report their nationality. Nevertheless, students will have the option not to answer any of the questions or leave the study at any point. Moreover, this is considered to be a minimal risk study. Lastly, the nature of this study proposal requires Institution Research Ethics Review Board (IREB) approval before being conducted. The IREB application will be submitted in the summer of 2021.

Study status

This research project is intended to start once the IREB approval is obtained (fall 2021).

Discussion

The rapid incorporation of online (distance) learning modalities to traditional (face-to-face) education has become more visible in the last years. Due to SARS-CoV-2 (COVID-19) pandemic, the recent mandatory safety measures, such as social distancing, have abruptly extended the online learning modalities

Table 1. Timeline chart of the research project tasks.

No.	Tasks	Months											
		1	2	3	4	5	6	7	8	9	10	11	12
1	Protocol preparation	■											
2	Data collection		■	■									
3	Data analysis				■								
4	Initial draft					■	■						
5	Final draft							■					
6	Submissions for publication								■	■			

to most academic institutions. Apart from blended learning, health education has constantly strived to implement the most sophisticated technologies available for an effective student deep learning outcome. The current project adds an innovative perspective to the advancement of health education since 1) most visual material available for students is still mainly based on 2D graphics, and 2) implementing VR/AR technologies in the learning setting has never been more feasible.

By introducing VR/AR to the dental pre-clinical traditional, blended, and fully online learning contexts, we hope to stimulate students to better understand the foundation material prescribed in the dental undergraduate curriculum.

Study strengths and limitations

One of the study's strengths is that, most likely, we will meet the sample requirement according to the power calculation described in the data analysis section. Thus, it is expected to include a representative Middle Eastern geographically rich sample (i.e., primarily Iraq and Syria) and transfer our findings to other Middle Eastern settings.

Regarding the proposal's limitations, the questionnaires to be used to assess students' perspectives will not be validated. However, there is an important overlap with similar previous studies²⁻⁴.

Implications for practice and research

This study could inform Asian dental educators of the feasibility of implementing AR/VR technologies to determine the effectiveness in a pre-clinical curriculum before expanding its use.

Study replication potential

This project has been designed and originally planned to be conducted in the UAE (Dubai and Ajman). However, this project can also be replicated in China (Beijing and Hong Kong) as the coauthors have recognized the value of such

an educational project and, in fact, they have submitted their respective IREBs.

Data availability

Underlying data

No underlying data are associated with this article.

Extended data

Mendeley Data: Undergraduate students responses to VR/AR in their dental education. <http://dx.doi.org/10.17632/2kycm5wwgt.1>⁵.

This project contains the following extended data:

- Informed Consent Form - Extended.pdf (consent form).
- A pre-test questionnaire-sample.pdf (research instrument A).
- A post-test questionnaire-sample.pdf (research instrument B).

Data are available under the terms of the [Creative Commons Attribution 4.0 International license](#) (CC-BY 4.0).

Acknowledgements

Kelvin Ian Afrashtehfar is an Assistant Professor in Prosthodontics at the College of Dentistry, Ajman University, UAE, an Associate Researcher in the Department of Reconstructive Dentistry and Gerodontology at the University of Bern School of Dental Medicine, Switzerland, and the Director of the Evidence-based Practice Unit in Ajman University.

We would like to thank the faculty and staff at the Ajman University College of Dentistry (M. Jaber, A. Jaghsi, R. Osman, Y. El-Karimi, and S. Ahmed) for agreeing to support one of the three sections of this research project.

The authors (KIA, AAHA, and MHS) thank Ajman University for supporting the present protocol study.

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7. Afrashtehfar KI, Eimar H, Yassine R, et al.: **Evidence-based dentistry for planning restorative treatments: barriers and potential solutions.** *Eur J Dent Educ.* 2017; **21**(4): e7–e18. [PubMed Abstract](#) | [Publisher Full Text](#)
8. Afrashtehfar KI, Bryant SR: **Understanding the lived experiences of North American dental patients with a single-tooth implant in the upper front region of the mouth treated in a university setting by postgraduate dental students: A qualitative study protocol.** *JMIR Res Protoc.* 2021. [PubMed Abstract](#) | [Publisher Full Text](#)

Open Peer Review

Current Peer Review Status:

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Reviewer Report 19 October 2022

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Kenneth Y. T. Lim

Office of Education Research, National Institute of Education, Singapore, Singapore

I am grateful for the opportunity to review your manuscript, which describes the perspectives of pre-clinical students with respect to the use of VR / AR within their curriculum.

The plan for your study is coherently presented to your readers. You may wish to perhaps consider a more explicit review of the extant literature, so that the research questions may be justified in a more contextualised manner.

You may also wish to include a brief section on any anticipated risks, and any consequent (tentative) measures you anticipate you might be able to take, should the need arise to mitigate risks.

Is the rationale for, and objectives of, the study clearly described?

The objectives are explicitly stated.

The rationale might be further improved by situating it more clearly within the literature. the authors are invited to elaborate on their understanding (as derived from literature) of the possible connections between the introduction of a spatial component in the dentistry curriculum through VR / AR and any resulting improvement in learner skillset.

Is the study design appropriate for the research question?

The study design is appropriate for the research questions.

Are sufficient details of the methods provided to allow replication by others?

The description of methods is currently not sufficiently specific. given that the study is yet to be conducted, an argument can reasonably be made that a more detailed description will follow upon completion of the actual study (which is pending IRB approval).

Are the datasets clearly presented in a useable and accessible format?

The question of datasets is not relevant to this manuscript, as the manuscript represents a proposed study and not one which has already been completed.

Is the rationale for, and objectives of, the study clearly described?

Yes

Is the study design appropriate for the research question?

Yes

Are sufficient details of the methods provided to allow replication by others?

Yes

Are the datasets clearly presented in a useable and accessible format?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: the learning sciences, pedagogy / andragogy, the use of VR / AR in learning

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 03 Dec 2022

Kelvin Afrashtehfar, Ajman,an University, Ajman City, United Arab Emirates

Reviewer #2 is thanked for providing suggestions for improving this manuscript. The positive comments about the completeness of the study protocol are appreciated.

1.- It is already mentioned that "this is considered a minimal risk study." However, it was added that students are considered a vulnerable population.

Thus, the data collected does not reveal their identity, and anonymity is always preserved. Additionally, they are free to participate or withdraw from the study at anytime. There are no benefits or penalization to the student's grades whether they decide to participate or not. To avoid influencing the student's participation in response bias, an independent third party will collect the data, and any identifiable data will not be accessed until the course grades have been finalized.

The informed consent will clearly state that participating in such a study has no educational benefit to the students.

2.- The rationale or justification of the appraised study is mentioned as "It is essential to evaluate the potential for adopting a VR teaching environment for UAE pre-clinical dental students when understanding and learning about each tooth's characteristics, head and neck components, as well as partial and complete removable dental prostheses. It is equally

important to assess the impact of VR in these courses, as perceived by the students." A hypothesis has also been provided.

The implications "Implications for practice and research" agree and connect the introduction rationale with the discussion by stating, "This study could inform Asian dental educators of the feasibility of implementing AR/VR technologies to determine the effectiveness in a pre-clinical curriculum before expanding its use."

3.- The author is thanked for providing a solution for addressing additional specifics regarding the methods. Thus, the reviewer's suggestion has been added to the manuscript text. "More detailed description will follow upon completion of the actual study (IREB approved)."

The sentence "This research project is intended to start once the IREB approval is obtained (fall 2021)" was changed to "This research project is intended to start in January 2023 as the IREB approval has been obtained."

The authors acknowledge reviewer #2 for providing comments to improve the submitted manuscript. We are delighted with the result.

Competing Interests: No competing interests were disclosed.

Reviewer Report 22 June 2022

<https://doi.org/10.5256/f1000research.56403.r137499>

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Anand Marya

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First of all I would like to thank the editor for inviting me to review this paper and secondly I would like to complement the authors on their hard work in compiling this manuscript. I do have some suggestions to help improve this manuscript:

1. Please do mention the mode of sampling which I think in this case is convenience sampling.
2. Is the post-test questionnaire blinded? Bias elimination as it is a single-center study.
3. What software/method has been used for sample size calculation and please expand on the power of the sample.

4. Please add notes on limitations of Likert scale.

5. Please consider the following papers:

a. Jaber M, Al-Samarrai B, Al-Obaidee A, Varma SR, Karobari MI, Marya A. Does General and Specific Traits of Personality Predict Students' Academic Performance?. *BioMed Research International*. 2022 Jan 4;2022.

This is an insightful study into the academic performance of students based on their traits which are very important factors to consider for any educational perspective study.

b. Veeraiyan DN, Varghese SS, Rajasekar A, Karobari MI, Thangavelu L, Marya A, Messina P, Scardina GA. Comparison of Interactive Teaching in Online and Offline Platforms among Dental Undergraduates. *International Journal of Environmental Research and Public Health*. 2022 Mar 8;19(6):3170.

This an undergraduate level study where an analysis is done on the comparison between interactive teaching using various platforms.

References

1. Jaber M, Al-Samarrai B, Salah A, Varma SR, et al.: Does General and Specific Traits of Personality Predict Students' Academic Performance?. *Biomed Res Int*. 2022; **2022**: 9422299 [PubMed Abstract](#) | [Publisher Full Text](#)
2. Veeraiyan D, Varghese S, Rajasekar A, Karobari M, et al.: Comparison of Interactive Teaching in Online and Offline Platforms among Dental Undergraduates. *International Journal of Environmental Research and Public Health*. 2022; **19** (6). [Publisher Full Text](#)

Is the rationale for, and objectives of, the study clearly described?

Yes

Is the study design appropriate for the research question?

Yes

Are sufficient details of the methods provided to allow replication by others?

Yes

Are the datasets clearly presented in a useable and accessible format?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Orthodontics, Oral Health, Dental education

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 03 Dec 2022

Kelvin Afrashtehfar, Ajman,an University, Ajman City, United Arab Emirates

The reviewer is acknowledged for providing suggestions for improving this manuscript. The authors have enjoyed reading and addressing every comment of the reviewer's report.

1. 'Convenience sampling' was added.

2. The post-test questionnaire will be answered after the exposure using the same form used for the pre-test questionnaire. This has been added, too.

3. G*Power software (ver. 3.1.9.7; Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany) will be used for sample size determination and power analysis. This has been included and cited.

Reference: Kang H. Sample size determination and power analysis using the G*Power software. J Educ Eval Health Prof. 2021;18:17. doi: 10.3352/jeehp.2021.18.17.

4. To comply with the reviewer's comment, "The development of the self-report survey tool includes an effort in maximizing validity and controlling for response biases (e.g., social desirability and acquiescent) in Likert scales," t was added.

Reference: Kreitchmann RS, Abad FJ, Ponsoda V, Nieto MD, Morillo D. Controlling for Response Biases in Self-Report Scales: Forced-Choice vs. Psychometric Modeling of Likert Items. Front Psychol. 2019 Oct 15;10:2309. doi: 10.3389/fpsyg.2019.02309.

5. The suggested references Jaber et al. 2022 and Veeraiyan et al. 2022 were revised as indicated. The listed authors decided by consensus that the following references are pertinent to comply with the reviewer's suggestions.

References:

Veeraiyan DN, Varghese SS, Rajasekar A, Karobari MI, Thangavelu L, Marya A, Messina P, Scardina GA. Comparison of Interactive Teaching in Online and Offline Platforms among Dental Undergraduates. International Journal of Environmental Research and Public Health. 2022 Mar 8;19(6):3170.

Lin GSS, Tan WW, Afrashtehfar KI. Exploring the Learning Experience of High-Performing Preclinical Undergraduate Dental Students: A Qualitative Study. Education Sciences. 2022; 12(11):801. <https://doi.org/10.3390/educsci12110801>

The authors appreciate the reviewer's intellectual effort and personal time to provide recommendations to benefit the appraised manuscript and the educational research community.

Competing Interests: No competing interests were disclosed.

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