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CASE STUDY

Student and lecturer perceptions of augmented and virtual reality in anatomy: A Sri Lankan case study

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I. INTRODUCTION

Anatomy is considered as one of the key components of undergraduate medical education. Hence, it is important to have a sound knowledge in anatomy to proceed into clinical medicine. Didactic lectures, textbooks, prosected specimens, and cadaveric dissection are the most frequently used anatomy teaching methods. However, with the emergence of COVID-19 pandemic, conventional teaching and learning were challenged. Technology integration for medical education has been increased during COVID-19 in many countries. With the integration of new technologies to the anatomy teaching, the traditional 'directed self-learning' started to move towards 'self-directed learning'. This transformation however, was not without various challenges, especially in low-resource settings such as Sri Lanka (Karunathilake et al., 2020). Augmented reality (AR), Virtual reality (VR), and principles of gamification play an important role in motivation and engagement in medical teaching and learning by enhancing interactivity (Moro et al., 2021). Such technologies also found to have positive impact on students' spatial understanding and 3D comprehension of anatomical structures.

The objectives of this case study were to identify the context-specific factors in designing AR/VR-based anatomy instructional materials and to assess the student motivation and engagement to use gamification in their studies. The instructional systems design model ADDIE (Molenda, 2003), which is an acronym for *Analyze,*

Design, Develop, Implement, and Evaluate, was used to develop the instructional materials in this study since it found to ensure the appropriateness of the materials used in an optimal manner to bring the maximum educational outcome.

II. METHODS

During the study, mixed-method tradition was followed in a Sri Lankan medical faculty from September 2020 to February 2021. Ethics approval was obtained from the Ethics Review Committee of the Postgraduate Institute of Medicine, University of Colombo where the study was exempted from the review process. Purposive sampling was the method adhered recruiting 92 undergraduate medical students and 20 lecturers with the informed consent of the participants. The methodology was phased out according to the ADDIE model.

A. Analysis

A qualitative study was conducted using semi-structured interviews with the lecturers. The interviews were informed by the six dimensions of the Hexagonal E-Learning Assessment Model - HELAM (Ozkan & Koseler, 2009) which consists of students' attitudes, teachers' attitudes, technology-enhanced learning, content quality, service quality and supportive factors in designing effective E-learning materials. This phase revealed lecturers' suggestions to develop AR/VR contents in terms of graphical user interfaces, modes of

navigation, interactivity, and strategies in incorporating modes of gamification into learning materials.

B. Design

The results of the analysis phase were used to develop a blueprint of the instructional materials integrating the modes of gamification. These were instrumentalised to enhance the motivation and engagement in developed learning materials.

C. Development

An AR/VR application was developed using *Unity* game engine using 3D anatomy models to project 3D anatomy models over 2D reference images to be used with smart phones and generic VR boxes.

D. Evaluation

This phase consisted of a quantitative study offered to undergraduate students. The self-administered questionnaire with 40 questions of the type 5-point Likert-scale was used to assess participants' self-reported perceptions of motivation and engagement in self-directed learning. The questionnaire assessed the gamification approach, teaching materials, user interfaces, practicability, physical discomfort, student attitudes on PC-based games, AR/VR apps. The developed apps were used by the students prior to complete the survey.

III. RESULTS

A. Qualitative Study

Lecturers expressed their interest in AR/VR technology with gamification and suggested to link the new AR/VR contents to the existing Learning Management System as the students already have a good engagement with it. They highlighted different modes of gamification such as interactive quizzes, animated interactive 3D anatomy models, teleport targets for VR navigation and video clips to enhance interactivity. Furthermore, they emphasized the importance of the quality of the content, reliability of the information technology services and course administration related factors to improve the overall quality of the learning experience and the sustainability of the new approach.

B. Quantitative Study

The results were organized along the dimensions, gamification, teaching materials, user interfaces, practicability, students' attitudes toward the technology-enhanced learning and AR/VR apps. The gamification dimension indicated the overall acceptance for the AR/VR techniques and tools and adapting the technology-enhanced learning in formal medical curricula. The highest mean value (4.20 out of the scale ranging from 1 to 5) was observed for the use of the augmented reality app indicating that medical students participated were satisfied with the offered interactivity in the AR/VR apps. The average satisfaction score for gamification, practicability, physical discomfort, teaching materials, user interfaces, student attitudes on the technology-enhanced game and AR/VR app were above satisfactory level (score $\geq$ 4). The student's satisfaction on the physical discomfort showed the lowest average score compared to the rest of the dimensions. Further to this, the students had lesser variation in the satisfaction score about the dimension attitudes on the technology-enhanced learning (SD 0.41) compared to the other dimensions. The questionnaire included six questions to measure the level of motivation and engagement. On average, 88% of the students have expressed their willingness to engage with the AR/VR learning style and confirmed that the technology-enhanced learning is a beneficial learning style.

IV. DISCUSSION

The study was conducted to identify the measures to improve motivation and engagement in learning anatomy when integrating technology-enhanced interactive learning contents into the undergraduate medical curriculum. The importance of having a systematic approach is necessary when designing instructional content to obtain a better outcome. The use of principles of gamification improved motivation and engagement which is in line with previous studies (Moro et al., 2022). Sustainability of the technology-enhanced learning was a key concern among the lecturers.

V. CONCLUSION

This research attempted to identify the student motivation and engagement towards the gamified anatomy learning with AR/VR technology. The study provided the insight into context-specific factors in designing interactive learning contents and methods. The ability to deliver an immersive experience in AR/VR methods helps the student to study anatomy in self-directed learning even in situations, such as COVID-19 pandemic and mandatory social distancing, which demands strict remote teaching.

Notes on Contributors

Dr G.K.M.E. Janaka, MBBS, MSc, MD was involved in reviewing the literature, formulating the methodological framework, designed the gamified AR and VR learning tools and and writing the original draft.

Dr Roshan Hewapathirana, MBBS, MSc, PhD, MIEE was involved in the study by developing the

methodological framework, data curation, formal analysis, and editing the original draft.

Professor Karunathailke Indika, MBBS(Col), CTHE (Col) DMedEd (Dundee), MMedEd (Dundee), FHEA (UK), FCGP(SL), FRCP (Edin.), FCME (SL) was involved in the study by conceptualizing the idea, developing the methodological framework, creviewing the manuscript and supervising the overall study.

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Declaration of Interest

The authors declare that they have no competing interests.

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