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The Perception of Medical Students on the Usefulness of the Respiratory Ventilatory Augmented Reality (ResVAR) Application for Learning the Respiratory System

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ABSTRACT

Augmented reality (AR) is a revolutionary technology with potential educational applications. When contemplating use of AR applications in educational settings, the ease of use of the application should be considered. Here we assessed students' perceptions regarding use of the Respiratory Ventilatory Augmented Reality (ResVAR) application in the context of learning a respiratory module. Clinical and preclinical students enrolled in the Faculty of Medicine and Health Sciences at Universiti Putra Malaysia (UPM) participated in a cross-sectional study. Study participants were first- to fifth-year medical students at UPM who were selected using a convenience sampling technique. A total of 173 participants completed a self-administered questionnaire. Data for the responses in this descriptive study were analysed using SPSS version 27. The data indicated that nearly all preclinical students (97%) and clinical students (94%) found the ResVAR are easy to use. In addition, nearly all preclinical students (98%) and most clinical students (88%) found the ResVAR are easy to read and understand. Nearly all (98% and 96% of clinical students and preclinical students, respectively) could use the application's tools on their own and nearly all (98% of preclinical students and 99% of clinical students) said that the application helped them learn more about the respiratory system. About 88% of clinical students and 98% of preclinical students said that the ResVAR helped them better focus on the subject, and in turn they gained a better understanding and image of the respiratory system. The large majority of students (almost 96% of preclinical students and 86% of clinical students) said that the ResVAR could increase the likelihood that they would pass a test about the respiratory system. Overall, both preclinical and clinical students thought that the ResVAR was a useful teaching tool that helped them better understand the respiratory system. The findings of this study suggest that integration of the ResVAR and other similar applications and software into medical curricula could yield significant advantages for students in terms of enhanced comprehension and study of the respiratory system.

Keywords: *Augmented reality, Respiratory system, Learning tool, ResVAR, Perceived usefulness*

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INTRODUCTION

Many lecturers at medical schools employ two-dimensional (2D) teaching techniques like lecture slides, white boards, quotations from medical texts, and other resources for conventional learning and teaching. However, augmented reality (AR) as a teaching tool or for visualisation assistance has been applied for medical instruction since the early 1990s (1). In teaching of topics like the ventilatory cycle, three-dimensional (3D) AR methods offer benefits over 2D teaching techniques by enabling medical instructors to explain the cycle in 3D to provide students with a better understanding of the concepts involved.

AR applications play a crucial role in the educational realm by facilitating dissemination of didactic content that would otherwise be challenging to convey. Incorporation of AR technology in educational endeavours has helped instructors attain elevated standards of excellence (1–3). Most scholarly investigations pertaining to the integration of AR in educational settings largely centre around theories of learning, with a particular emphasis on constructional and situational learning theories (4). The methodology by which students obtain knowledge through use of externally derived material is important to comprehend and enhance their understanding, and should align with concepts associated with deep learning techniques. Integration of AR into medical education offers students a respite from the repetitive nature of traditional textbooks and other text-based learning materials. Moreover, the COVID-19 pandemic necessitated a shift from traditional teaching methods to the adoption of digital teaching tools like AR on a worldwide scale (1).

There are numerous rationales for use of AR as an instructional and learning instrument. AR improves the educational experience through increased interactivity and engagement. By captivating students, AR can enhance the enjoyment of the educational process (5). The interactive and immersive qualities of AR have the potential to inspire students to engage actively in the educational experience. The superimposition of digital data onto the physical environment enabled by AR facilitates a connection between abstract principles and practical implementations. By offering practical, hands-on experience within a controlled setting, AR facilitates student comprehension of the relevance of the acquired knowledge to real-life situations (6). AR facilitates visualisation of abstract concepts to reinforce comprehension of intricate ideas through 3D or interactive representations. Through these features AR could revolutionise multiple disciplines like science, geography, and history by imbuing scientific phenomena, geographic locations, and historical events with vitality (7). AR applications also allow students to progress at their own pace and in accordance with their unique learning styles. Adaptive learning experiences and personalised feedback can be incorporated into AR tools to meet specific requirements of every student (8). Technological advances have made AR tools more accessible and affordable, making them a cost-effective alternative to conventional educational resources. AR enables effortless updates to digital content, ensuring that educational materials remain current and pertinent. Integration of AR prepares students for a future dominated by technology by acquainting them with emerging technologies (9). As such, AR satisfies skills requirements of a workforce that is undergoing rapid change and in which technology plays an important role.

The Respiratory Ventilatory Augmented Reality (ResVAR) application features a quiz with five multiple-choice questions, a 2D animation of the ventilatory cycle graph, and an AR image of the lungs. The application was created from scratch by the Universiti Putra Malaysia (UPM). Due to the inclusion of AR for lung anatomy, ResVAR stands out from rival applications in the Google Play Store like “respiratory system anatomy” and “respiratory system”. The application includes respiratory system subjects that are illustrated by diagrams, brief videos, and texts. The anatomy and physiology of how the body functions

during respiration can therefore be better understood by students. To effectively educate students about lung functions, 3D-AR can be used together with several other related 3D animations. A user's perspective of the real world overlaid with a computer-generated image using 3D-AR photography technology would be optimal. Compared to traditional teaching methods, this 3D technology would better help medical students learn about and evaluate the respiratory system. Installing the application on mobile and lightweight Android phones is simple. The application's keywords, vibrant AR, movies, and animation can work as a catalyst to boost students' passion for learning. ResVAR represents additional learning tool for students and lecturers alike as pictured in Figures 1 and 2.

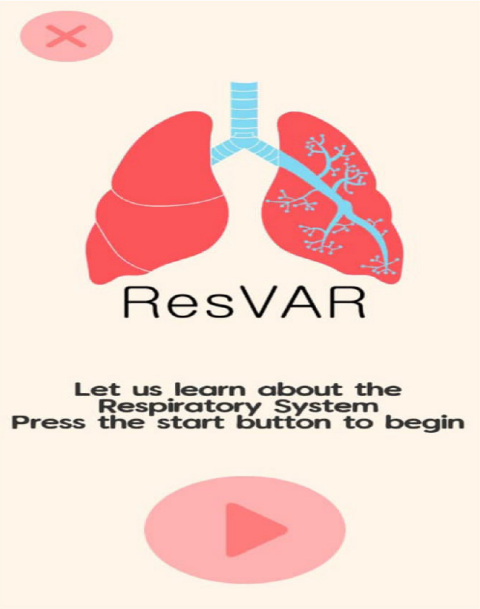

Figure 1: ResVAR interface.

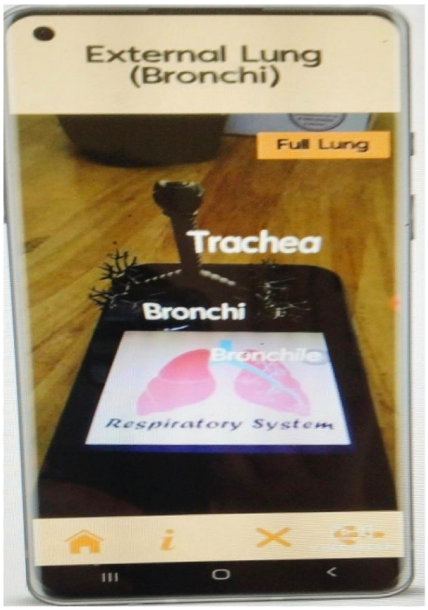

Figure 2: AR display of the bronchus.

In this study, we assessed the perceptions of students about use of the ResVAR during medical education and training. These perceptions include the primary objectives of AR-based learning, including enhancing comprehension and facilitating transmission of complex material. The rationale for incorporating AR into educational settings is in its capacity to boost engagement, offer authentic contextualisation, cater to diverse learning modalities, promote collaborative learning, and equip students with the necessary skills to navigate forthcoming obstacles.

METHODS

This study was conducted at the Faculty of Medicine and Health Sciences at UPM. This was a cross-sectional study involving first- to fifth-year medical students at UPM who were inclusively enrolled in the 2021/2022 academic year. Students using non-Android mobile phones were excluded since currently the ResVAR can only be downloaded on an Android phone. Of the 550 medical students at UPM, 173 were enrolled, which satisfied the necessary anticipated sample size determined through sampling calculation based on the proportion values from a study done by Cabero-Almenara et al. (10). Convenience sampling was used for this investigation.

The survey was distributed to all medical students in their first to fifth year of study using a name list obtained from the administrative office. Each student was informed about the study via the messaging platform, WhatsApp. The research was carried out over a three-month period with the ResVAR used by students in both the preclinical and clinical phase of training. The students were first given training sessions to familiarise themselves with the functionalities of the ResVAR.

The students were then sent a link to a Google Forms-based online questionnaire via WhatsApp. The study data consisted of responses to the self-administered survey. The closure of the Google Forms survey occurred promptly upon attainment of the predetermined threshold of respondents. The questionnaire had 10 questions that were answered using a two-point Likert scale, which was used for its simplicity and comprehensibility, as well as to decrease cognitive burden and reduce potential confusion. The survey was modified based on a study by Davis (11) and was designed to assess the usefulness and ease of use of the ResVAR. After examining the findings, the questionnaire was adjusted to improve its readability and clarity. To conduct the face validation component of this study, a second study population that was 10% the size of the overall sample population was used. Face validation is the process of having professionals in the field examine the appearance and content of a measurement tool to see if it appears to measure what it is intended to measure. This helps determine the validity or accuracy of the tool.

In this subset, the survey was administered to preclinical first-year medical students at another university, Universiti Sains Islam Malaysia. Results for participants who were involved in the subset were not included in the sample data. All inquiries were satisfactorily addressed, with no unanswered questions and no student queries. The reliability assessment was conducted via Cronbach's alpha. For this pretest, the perceived usefulness of the ResVAR had Cronbach's alpha and perceived usability scores of 0.775 and 0.792, respectively. These results are lower than those from a study by Cabero-Almenara et al. (10), which were > 0.8, but were still > 0.5, thus demonstrating good internal consistency. Data gathered for this descriptive study were analysed using SPSS version 27.

RESULTS

Of the 173 study participants who completed the survey, 73 and 100 individuals were in the preclinical and clinical phases, respectively, of training.

Most study participants in both the preclinical and clinical years had a positive perception of the usefulness of the ResVAR (Table 1). Nearly all preclinical (97%) and clinical students (94%) found ResVAR to be user-friendly. The readability and comprehensibility of the ResVAR were high among both preclinical students (98%) and clinical students (88%). Very few students needed assistance to use the software as evidenced by 96% of preclinical students and 98% of clinical students reporting that they could use the software without help. Notably, almost 98% of preclinical students and 99% of clinical students found the ResVAR useful for learning about the respiratory system, and approximately 98% of preclinical students and 88% of clinical students found that the application helped them concentrate better on the subject, which in turn improved their understanding and capacity to visualise the respiratory system. In addition, 96% of the preclinical students and 86% of the clinical students felt that use of the ResVAR would help them pass an exam concerning the respiratory system.

Table 1: Perspectives of UPM preclinical and clinical medical students on use of the ResVAR

Question	Perception of intervention group cumulative frequency (%)			
	Preclinical (n = 73)		Clinical (n = 100)	
	Agree	Disagree	Agree	Disagree
Q1. The way that system information is presented is clear and understandable.	71 (97)	2 (3)	91 (91)	9 (9)
Q2. Tasks can be performed in a straightforward manner using this software.	70 (96)	3 (4)	98 (98)	2 (2)
Q3. It is easy to move from one part of a task to another.	70 (96)	3 (4)	91 (91)	9 (9)
Q4. I can understand and act on the information provided by this software.	70 (96)	3 (4)	100 (100)	0 (0)
Q5. Overall, I find this software easy to use.	71 (97)	2 (3)	94 (94)	6 (6)
Q6. Using this software makes my learning more productive.	72 (98)	1 (2)	88 (88)	12 (12)
Q7. The use of this software during the classes will increase my comprehension of certain concepts.	72 (98)	1 (2)	88 (88)	12 (12)
Q8. I believe that this AR material will help me pass an exam.	70 (96)	3 (4)	86 (86)	14 (14)
Q9. The software enhances my understanding of the topic.	71 (97)	2 (3)	99 (99)	1 (1)
Q10. Overall, I find this software useful for my learning.	71 (97)	2 (3)	90 (90)	10 (10)

DISCUSSION

Merging of real-world environmental inputs and digitally generated 3D representations is made possible by the relatively recent technology termed AR (2). AR may employ smartphones, tablets or other devices to create an immersive learning environment and an extremely stimulating learning experience (1). In healthcare, retail and marketing, education, military, travel and tourism, auto industry, manufacturing, architecture, and engineering settings AR applications are in use or under development. They are also utilised extensively in industry (3). Medical institutions worldwide are rapidly embracing AR-based teaching systems due to the unique learning benefits it offers, such as remote learning and interactive simulations (1). These advantages are highlighted by the COVID-19 pandemic, which sparked an even greater shift towards online learning (4).

In an earlier study, anatomy learning applications using mobile AR technology received positive feedback from respondents who were students in Indonesia, which is in accordance with the results of this study (12). Some experiences with AR applications in schools have shown highly positive results. For example, a mobile system based on AR used for learning chemistry in secondary education stimulated students' understanding and retention of learned material, while increasing their motivation (13). Other experiences in primary education showed that AR also contributed to improved learning, motivation, and the understanding of concepts (14–16).

Similar to the present investigation, prior studies to investigate AR applications have also demonstrated enhanced learning and positive attitudes among students who used AR (17). Increased comprehension, motivation, and creativity (18) was also reported, as were

favourable perceptions regarding implementation of AR in education (19), heightened motivation and improved learning (20), a strong inclination to use AR in the future (21), and increased student motivation, innovation, creativity, and engagement (22). Despite these advantages, integration of AR into university curricula has encountered several challenges, the most prominent being the scarcity of AR educational aides, the limited amount of research on the applicability of AR, and the restricted resources at higher education institutions (23). Nonetheless, there is a growing trend among university professors to incorporate AR technology into their course designs (24, 25). There thus is the possibility to use AR as an educational tool that can enhance students' learning experience and promote information retention by means of their engagement with smartphone-based activities. This potential is particularly evident when considering use of the ResVAR.

Limitations

The use of a two-point Likert scale in the questionnaire could restrict the amount of information that can be obtained. The determination of causation and effect is limited in this study due to its cross-sectional design. In addition, the temporal validity of the study cannot be guaranteed to be representative. Other limitations include the restricted applicability and generalisability due to the small sample size of medical students from Universiti Putra Malaysia, which may not accurately represent the entire population of medical students.

In addition, enrolling just Android users may be a constraint for an application if its target user base includes people who do not use Android devices. By restricting enrollment to Android users, the program may exclude potential users who use other operating systems, such as iOS or Windows. This could lead to a limited audience, thereby limiting the application's reach and adoption.

CONCLUSION

ResVAR offers educators an opportunity to assist students in understanding of difficult concepts. In addition, the preclinical and clinical students found ResVAR to be a valuable educational tool for enhancing their comprehension of the respiratory system. Teachers can improve learning experiences in the classroom, impart new knowledge, stimulate students' minds, and encourage them to pursue new academic interests through the interaction and experimentation that the ResVAR technology provides. The enhanced engagement with smartphone-based AR applications can enhance students' learning experience and aid in information retention by means of increased engagement as evidenced by the findings here for the ResVAR.

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ETHICAL APPROVAL

The UPM Research Ethics Committee granted consent for this study under ethical approval code JKEUPM-2022-171.

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