Comparison between virtual reality and traditional lecture methods in educating respiratory therapy on pediatric airway diseases

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Abstract

Background: Pediatric airway diseases are associated with complex challenges because of smaller and more dynamic airway structures in children. These conditions, should be immediately and precisely recognized to prevent life-threatening obstructions and long-term respiratory complications. Recently, virtual reality (VR) has emerged as an innovative approach to clinical medical education. To evaluate and compare the effectiveness of VR-based education and traditional lectures in enhancing knowledge retention, clinical reasoning, and motivation among senior respiratory therapy students.

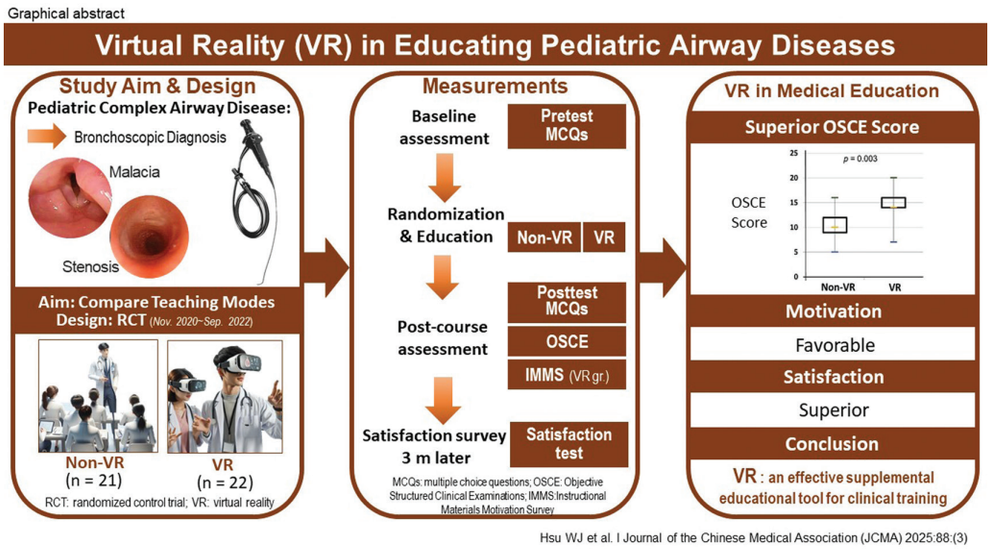
Methods: This study was conducted between November 2020 and September 2022, involving 54 students from a School of Respiratory Therapy, with 43 completing a pretest and undergoing random assignment into either a VR or a traditional education (non-VR) group. Samsung Gear VR Oculus headsets were used by the VR group for instructions on conditions such as laryngeal malacia, subglottic stenosis, and tracheomalacia. Theoretical exams, objective structured clinical examinations (OSCE), and instructional material motivation survey (IMMS) were used to evaluate participants' knowledge retention, clinical reasoning, and application capabilities, followed by a statistical analysis comparing both study groups.

Results: No significant differences in pretest scores were observed between the two groups. However, the VR group outperformed the non-VR group in OSCE scores significantly (15 ± 3 vs 10 ± 3, $p = 0.003$) and demonstrated greater learning motivation and satisfaction based on IMMS scores. No notable difference in immediate posteducation theoretical examination scores was observed between the groups.

Conclusion: VR can effectively serve as a supplemental educational tool in clinical training programs for pediatric airway disease. To optimize its implementation in medical educational settings, further research with larger cohorts and longer follow-up periods is needed.

Keywords: Children; Medical education; Virtual reality

Graphical abstract



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1. INTRODUCTION

The airway management for children, particularly neonates and infants, is complicated because they possess distinct anatomical features such as a proportionally larger head, shorter neck, larger tongue, and higher larynx. These anatomical differences should be mastered to avoid management complications.[1–3] Effective management of pediatric airway disorders not only mitigates immediate health risks but also influences long-term health and quality of life, affecting their growth, development, and daily activities.[4,5] Training that focused on pediatric airway management, involving pediatric-specific airway equipment and adapted techniques, prepares students for clinical practice. Early training establishes a foundation of critical skills that can positively affect children with difficult airways.

Medical and respiratory therapy students should understand pediatric difficult airway diseases. Pediatric patients present unique anatomical and physiological challenges compared to adults, requiring specialized knowledge and skills in airway management. Laryngomalacia, tracheomalacia, and subglottic stenosis pose serious risks, including life-threatening airway obstructions. Thus, students should be properly equipped to recognize and manage these conditions to enhance patient outcomes.[1,4]

In the rapidly evolving field of medical education, incorporating technology has become integral to achieving educational goals. The use of technology aims to facilitate basic knowledge acquisition, improve decision-making abilities, enhance perceptual variation, develop skill coordination, provide practice for rare or critical events, promote team training, and improve psychomotor skills.[6] Effective education is crucial in fostering students' expertise, and immersive technologies have been reportedly particularly beneficial for the learning motivation and competency of medical students.[7] Consequently, several medical educational programs have experimented with multimedia approaches to increase learning efficiency and student engagement. Virtual reality (VR) is a technology that can simulate varied clinical conditions, allowing users to enter simulated world and experience various real-world situations closely resembling actual clinical scenarios. This immersive experience captures the user's attention and thereby improves learning effectiveness.[7]

In the field of medical education, VR simulations can be applied in diverse disciplines, including anatomy education, surgical skills development, emergency medicine training, and nursing education.[8–11] Although conventional education often relies on oral or written examinations to assess students' competence in essential professional knowledge, clinical reasoning and application evaluation have proven to be less efficient. The objective structured clinical examination (OSCE) has emerged as an effective assessment method for medical students. It uses short simulated clinical scenarios to assess clinical reasoning, data interpretation, interviews, clinical examination, and management strategy application. Harden and other British scholars introduced the OSCE protocol in 1975 to evaluate the clinical competence of medical students.[12] Asian countries gradually adopted this examination method in the 2000s, and Taiwan officially included OSCE in the national examination for physicians in 2009. Furthermore, other healthcare professionals, such as dentists, Chinese medicine physicians, and pharmacists, are considering the inclusion of OSCE in their national examinations.[13]

Respiratory care plays a critical role in acute and critical care settings, where providing safe medical care is of utmost importance. Severe consequences may occur with delayed medical decisions in such situations. In Taiwan's current 4-year respiratory therapy program, first- to third-year students primarily engage in on-campus learning. However, the efficacy of virtual education in teaching clinical reasoning and application remains inadequately explored, particularly in respiratory therapy. Therefore, further studies are required to evaluate the effectiveness of virtual education in enhancing the reporting of clinical reasoning and application.

This study aims to compare the results of written examinations and OSCE tests after VR or traditional educational program for undergraduate respiratory therapy students. This study assessed the differences between these two educational approaches to better understand the potential benefits of VR in enhancing clinical medical education for undergraduate students.

2. METHODS

The institutional review board of Taipei Veterans General Hospital approved this study, confirming compliance with all pertinent ethical and regulatory standards under the approval reference number 2020-09-001CC.

This study delineated conventional instructional strategies as teachings conducted via lecture formats in a classroom setting. Conversely, the VR-based education used a Samsung Gear VR Oculus headset and a single-handed remote control, focusing on imparting knowledge regarding the pathological changes in laryngeal malacia, subglottic stenosis, and tracheomalacia, along with the clinical management of these conditions.

2.1. Participants

This experimental research was conducted from November 2020 to September 2022 and targeted fourth-year respiratory therapy specialization students at the School of Respiratory Therapy, who have already been trained in pediatric intensive respiratory care. Informed consents were procured before the commencement of the study. Thereafter, a pretest assessing knowledge on pediatric bronchoscopy, encompassing 12 multiple-choice questions, was administered. Only students who completed this pretest were considered eligible for the study.

Subsequent to the selection process, participants were randomly assigned to two educational groups: VR and traditional (non-VR). To evaluate immediate learning outcomes, both groups underwent a theoretical examination postinstructional sessions. This examination, including the same 12 multiple-choice questions, also assessed knowledge retention. An OSCE was used to further assess clinical reasoning and application abilities. Moreover, participants in the VR group were instructed to complete the instructional material motivation survey (IMMS) to evaluate motivational levels induced by the VR teaching method. A follow-up questionnaire distributed 3 months post-experiment probed long-term effects and satisfaction regarding this instructional approach in future clinical settings. A single faculty member graded all the assessments, with straightforward multiple-choice questions in theoretical tests and a scoring checklist used for the OSCE. Statistical analysis was conducted on the responses from multiple-choice tests.

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The test validity was authenticated by five field specialists, spanning areas such as pulmonology, education and teaching, pediatric intensive care, public health statistics, and clinical respiratory therapy. These experts rated and provided feedback for each test item, facilitating a content validity index (CVI) score. A CVI score of ≥0.8 was deemed valid.[14] Cronbach α was performed for test reliability, with a separate cohort of students not involved in the study. A Cronbach α value of >0.7 denoted adequate reliability; for theoretical tests, a value of 0.735 was obtained.[15,16] The Chinese version of IMMS was used, with sections covering satisfaction (questions 1-6) and other pertinent factors (questions 7-15), including one item requiring reverse coding.[17–19]

After the study, the long-term effects of this educational experience on clinical practice were evaluated over a 3-month dimension. The scoring methodology of OSCE was further refined by the Division of Clinical Skills Training at Taipei Veterans General Hospital, with examiners certified in instructor training by the Taiwan Society for Respiratory Therapy.

2.2. Statistical analysis

The *t* test was performed to compare performance scores between the two study groups. The Mann-Whitney *U* test was used to evaluate nonnormally distributed independent variables. The linear regression analysis was performed to determine the significance of different factors. All statistical evaluations were conducted utilizing Statistical Package for Social Science version 20.0 (SPSS, Chicago, IL), setting the significance threshold at 0.05.

3. RESULTS

3.1. Participant characteristics

A total of 54 students consented to participate in the study. Among them, 43 completed the pretest and were deemed qualified for inclusion, after which they were then randomized into two educational groups: VR (n = 22) and traditional (non-VR) (n = 21) (Fig. 1). The average initial pretest scores were 63.6 ± 8.7 and 58.7 ± 11.7 for the VR and non-VR groups, respectively, without significant distinction between them ($p = 0.121$). Demographically, each group comprised six males (27.3% in VR and 28.6% in non-VR), with the mean age closely matched at 22.3 years for VR and 22.2 years for non-VR, indicating no significant disparities in age or sex distribution ($p > 0.05$) (Table 1).

3.2. OSCE score and satisfaction comparison

The VR group exhibited a notably higher mean OSCE score (15 ± 3) compared to the non-VR group (10 ± 3), with the difference achieving statistical significance ($p = 0.003$) (Table 2, Fig. 2). Linear regression analysis revealed the positive influence of VR educational methods on OSCE performance ($p < 0.001$). Furthermore, a questionnaire derived from the IMMS was used to explore learning motivation and satisfaction, with feedback collected via a Likert scale from zero to four. The relevance and satisfaction metrics of the IMMS questionnaire yield predominantly favorable results (Fig. 3). A 3-month poststudy evaluation demonstrated elevated satisfaction levels with the VR instructional approach compared to the non-VR group in clinical practice settings (Fig. 4).

3.3. Theoretical test score comparison

Table 3 lists the mean scores attained by students in both educational study groups between pretheoretical and posttheoretical assessments. The total and part-1 (bronchoscopy knowledge) scores were significantly higher at posteducation than at preeducation test in both study groups ($p < 0.01$). Furthermore, no significant difference was observed in the scores of the pre-education or immediate post-education theoretical examinations between the two groups regarding their knowledge of pathophysiology ($p > 0.05$).

4. DISCUSSION

The study revealed that the OSCE scores of the VR group were significantly higher than that of the non-VR group, showcasing the positive effects of VR educational methods on clinical reasoning and application skills. Although VR education was associated with heightened motivation and satisfaction among students both immediately after instruction and during the 3-month follow-up, no notable difference was observed in the posteducation theoretical examination scores between the two

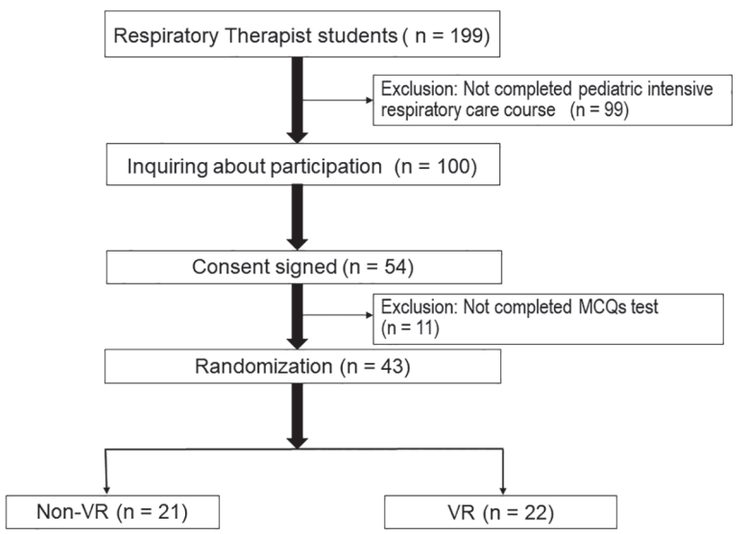

Fig. 1 Flowchart of participant selection and allocation into VR and non-VR groups. VR = virtual reality.

Table 1

Characteristics of VR and Non-VR groups

	Non-VR (n = 21)	VR (n = 22)	*p*
Age	22.2 ± 2.6	22.3 ± 0.8	0.890
Male	9 (28.6%)	6 (27.3%)	0.914
Pretest	58.7 ± 11.7	63.6 ± 8.7	0.121
Part-1	35.8 ± 9.3	37.1 ± 6.3	0.603
Part-2	22.9 ± 5.8	26.2 ± 7.1	0.099

Data are presented as mean ± SD or number (%).
Part-1 = clinical bronchoscopy; Part-2 = pathophysiology.

Table 2

OSCE scores of enrolled students between VR and non-VR groups

Group	Non-VR n = 21	VR n = 22	*p*
Mean	10 ± 3	15 ± 3	0.003
Median	10 [9, 12]	14 [14, 16]	

Data are presented as mean ± SD and medium [interquartile range Q1, Q3].
VR = virtual reality.

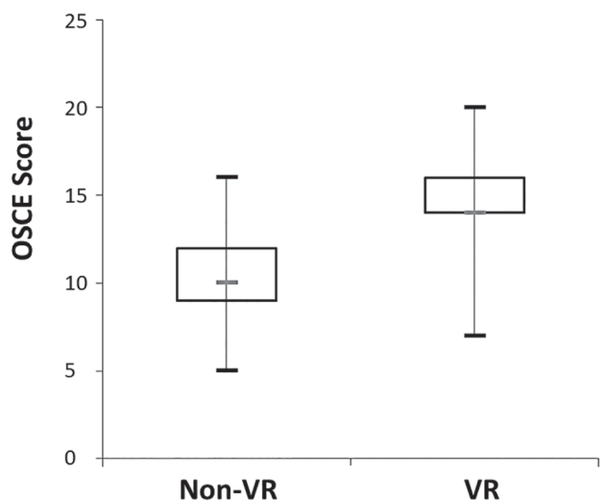

Fig. 2 Bar chart of mean OSCE scores for VR and non-VR groups, indicating that the VR group scored higher than the non-VR group ($p = 0.003$). VR methods are beneficial to OSCE by linear regression ($p < 0.001$). OSCE = objective structured clinical examination; VR = virtual reality.

groups. Our findings indicate that virtual education significantly enhances knowledge application abilities, but does not markedly influence knowledge acquisition compared to traditional methods.

Virtual education is increasingly becoming prevalent in medical training. A review of studies on continuous medical education conducted from 1996 to 2004 through both virtual and traditional methods found a general preference for virtual education,[20–22] a sentiment echoed by a 2016 study highlighting VR's benefits in teaching complex anatomy to nursing students, particularly for enhancing decision-making in emergency scenarios.[23] A study from Portugal demonstrated that virtual learning improves knowledge retention, clinical reasoning, and learner satisfaction in nursing education.[24] Our study concurs with these findings, indicating that VR education can significantly boost clinical reasoning and satisfaction levels compared with traditional methods, although different theoretical knowledge gains were not statistically significant. Leflore et al[25] reported that virtual patient trainer may be an effective substitute to achieve learning outcomes typically met using a traditional lecture format. Similarly, our study revealed that students in virtual education group gained significantly higher scores in the clinical reasoning knowledge application and increased the satisfaction compared with the traditional education group. Our study result on the knowledge theory demonstrated that the virtual education group also gained a higher score on the written test compared with the traditional group; however, this difference did not reach statistical significance.

A systematic review conducted by Lucena-Anton et al[26] reported inconclusive results regarding learning satisfaction and academic performance between VR and AR-based teaching models and traditional methods, suggesting that they are equally effective without clear advantages. Conversely, our study on respiratory therapy students demonstrated that the VR group significantly outperformed the non-VR group in practical skills as measured by OSCE scores and revealed greater learning motivation and satisfaction according to IMMS scores; however, no significant difference was observed in immediate posteducation theoretical examination scores. Both the review and our study demonstrate and indicate the potential benefits of VR/AR in medical education, particularly by enhancing practical skills, engagement, and satisfaction among students.

Although this study found that virtual education can elevate learner satisfaction and enhance learning outcomes, the relatively high cost associated with VR, comprising expenses for acquiring and maintaining VR headsets and adapting content into VR formats, should be considered. Moreover, the potential for VR to foster antisocial behavior, isolation, and impede human interactions underscores the need for viewing it as a complement rather than a substitute for traditional teaching approaches.[27] Therefore, VR learning may be implemented as a complement rather than a replacement for traditional teaching in medical care education.

The strengths of this study lie in its dual evaluation of knowledge acquisition and application via written tests and OSCE, using validated and reliable assessment tools, specifically focusing on respiratory therapy education—a novel approach within the scope of VR educational research.

This study faces several limitations, including the small sample size restricted to fourth-year respiratory therapy students at a single institution and a short-term outcome focus, challenging the generalizability and long-term applicability of our findings. The specific VR setup used, targeting select pediatric airway conditions, raises further questions regarding the uniformity and effectiveness of VR across different areas of respiratory therapy education. Future studies could enhance understanding by expanding the sample size, extending follow-up durations, diversifying VR content, and using more standardized and objective evaluation methods.

In conclusion, clinical reasoning and application skills of respiratory therapy students are more significantly enhanced by VR-based education than traditional lecture methods. VR learning also increased students' motivation and satisfaction, indicating a more immersive and effective educational experience. However, immediate knowledge retention was not improved by VR compared to traditional approaches. These results reveal that VR may be best utilized as a supplemental educational tool rather than a standalone solution in clinical training programs. Despite the promising benefits of VR in improving practical skills and learner engagement, the higher costs associated with its implementation and maintenance should be carefully considered. Future studies with larger sample sizes, extended follow-up periods, and more

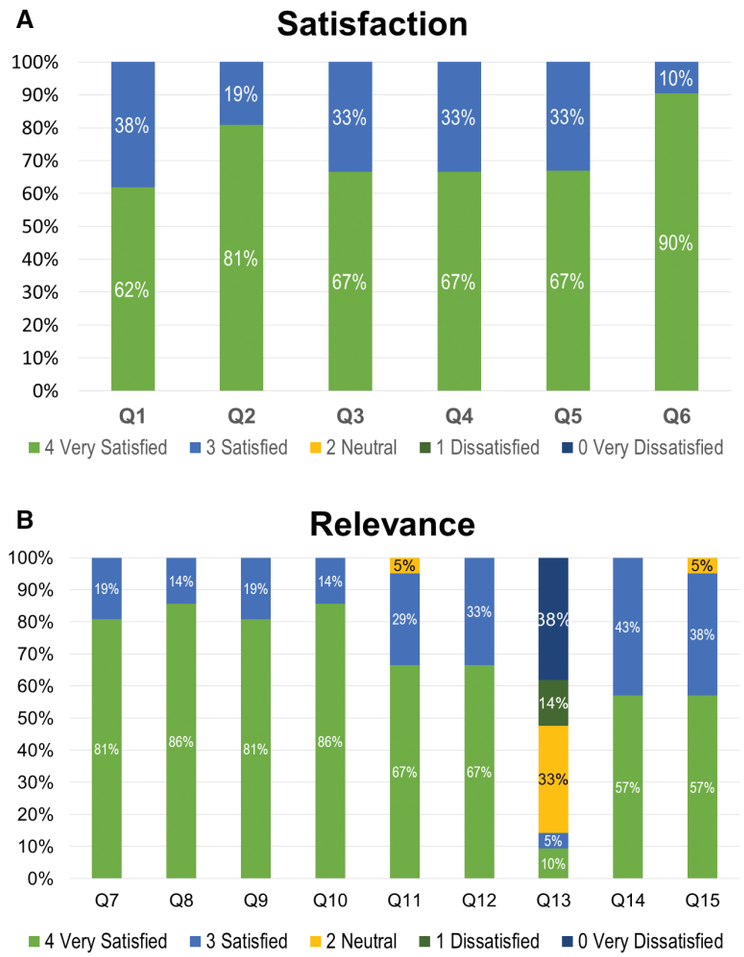

Fig. 3 Graphical representation of instructional material motivation survey questionnaire responses on learning motivation and satisfaction: A, satisfaction and (B) relevance. The results indicate positive feedback in relevance and satisfaction metrics for both educational methods on a scale from 0 to 4 (0, very dissatisfied; 1, dissatisfied; 2, neutral; 3, satisfied; 4, very satisfied), but Q13 is a reverse-coded item.

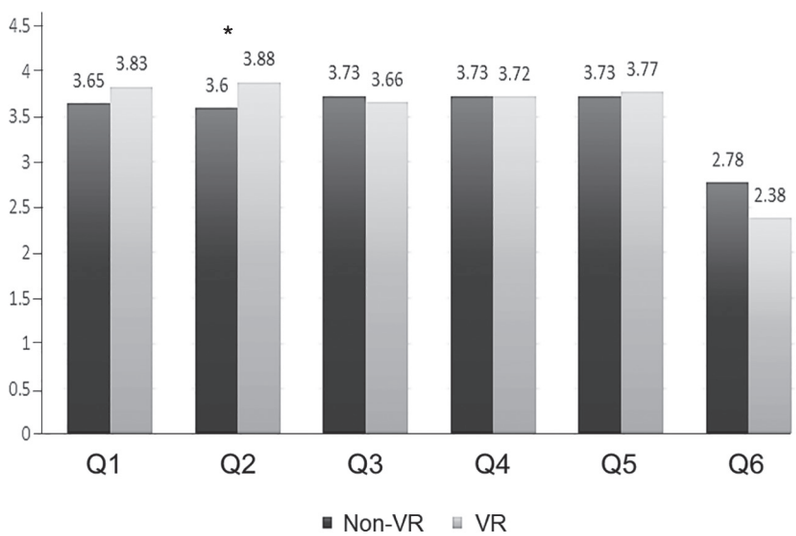

Fig. 4 Comparative satisfaction levels in clinical practice settings 3 mo poststudy depicted through a bar chart contrasting elevated satisfaction between the VR and non-VR group (0, very dissatisfied; 1, dissatisfied; 2, neutral; 3, satisfied; 4, very satisfied). *$p < 0.05$. VR = virtual reality.

Table 3

Preeducational and posteducational sore comparisons of theoretical tests of VR and non-VR groups

	Pretest	Posttest	Δ	*p*
Non-VR (n = 21)				
Total	58.7 ± 11.7	66.7 ± 12.5	+8.0	0.001
Part-1	35.8 ± 9.3	43.4 ± 10.6	+7.6	0.000
Part-2	22.9 ± 5.8	23.2 ± 7.1	+0.3	0.083
VR (n = 22)				
Total	63.6 ± 8.7	74.2 ± 13.6	+10.6	0.000
Part-1	37.1 ± 6.3	45.1 ± 11.7	+8.0	0.006
Part-2	26.2 ± 7.1	29.1 ± 5.8	+2.9	0.119

Data are presented as mean ± SD.

Δ = (pretest values) − (posttest values); Part-1 = clinical bronchoscopy knowledge; Part-2 = pathophysiology knowledge.

diverse VR content would further elucidate the long-term effects and optimal integration of VR in respiratory therapy education.

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