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Immersive Virtual Reality in Vocational School: A Systematic Literature Review

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Abstract

Immersive virtual reality technology is widely used in the field of education with the continuous development of hardware and software.Facing the content of skill practice that is changing with the times, vocational education is also actively reforming its teaching methods and applying IVR to teaching.This paper presents a systematic review of the applications, advantages, and challenges of IVR in vocational education.The study is based on the PRISMA report and analyses journal papers retrieved from Web of Science and Scopus, spanning the period from 2021 to 2025.It highlights the pedagogical value of IVR in teaching and learning, describes the challenges of its implementation in vocational education, and makes recommendations for future research.Although IVR is gradually being integrated into classrooms in vocational education and has been shown to have a positive impact on factors such as student learning outcomes and motivation, challenges such as cognitive load, motion sickness, and instructional design difficulties should not be ignored.Future research should focus on exploring the effects of IVR across different disciplines and different ways to address the negative impacts of IVR.This paper identifies research gaps, broadens the scope of research, and points the way for researchers and software designers.

Keywords: Immersive Virtual Reality, Vocational School, IVR, Vocational Education, Teaching

Introduction

With the development of science and technology, vocational education faces new opportunities and challenges.At present, the importance of vocational education is gradually increasing in various countries, for example, China revised and passed a new vocational education law in 2022, which requires vocational education to have the same status as general education (2022).In 2023, the Malaysian government put forward the "TVET" programme and, through a series of measures, such as increasing the special funding (Aziz & Subramaniam, 2023). With the industries developing so fast, the teaching methods and contents of vocational education should also evolve with the times.It is therefore crucial to find practical and effective ways to keep vocational education abreast of developments in front-line production technology.

The application of IVR technology may become an important way to improve the quality of vocational education and meet the needs of the industry.Immersive Virtual Reality (IVR) is an interactive technology that uses computers to generate high fidelity environments and immerses the user in a virtual scene by isolating the user from the display through a special hardware device (Biocca, 1995).IVR is defined in relation to those non-immersive VR, such as virtual space images demonstrated through computers, which is often referred to as Desktop Virtual Reality.The most common implementations of IVR include head-mounted displays (HMDs) and Cave systems, etc. As IVR technology matures and head-mounted displays become more popular, more and more people are using the technology in a variety of industries, such as healthcare, industry, and so on.

In the field of education, IVR has also been proven by many to have a number of advantages; For example, in K-12 education, teachers often use VR technology to learn about biological cells, the macroscopic universe, and other knowledge that cannot be directly accessed and is difficult to understand (Wu et al., 2020).Many researchers have explored the effects of IVR on learning outcomes, motivation, etc. through empirical studies (Liu et al., 2020; Parong & Mayer, 2021). Moreover, Makransky and Petersen (2021) have proposed a theoretical model of cognitive-emotional theory with regard to IVR. The possibility of IVR combined with online pedagogy has also been explored since the outbreak of the COVID-19 (Hall et al., 2019). Sachs (2018) presents a prediction that by 2025 there will be 15 million learners of virtual reality and related technologies.

Obviously, it is significant to understand the application of IVR in vocational education as well as its specific application.On the one hand, IVR allows students to practice practical skills repeatedly in a safe, low-cost environment by simulating real work scenarios at low cost.This can enhance their hands-on skills and understanding of the profession, thus improving their competitiveness in employment.On the other hand, IVR can provide convenience for teachers to create vivid teaching scenarios, enrich teaching resources and improve the effectiveness of teaching.In summary, exploring the application of IVR in vocational education can better align vocational education with industry needs and cultivate talents that are more in line with market demands.

Most of the previous research on the use of IVR in education discusses K-12 and higher education (Natale, et al., 2020), with few articles exploring the use of IVR in vocational education.The nature and content of vocational education is very different from general education, which is more about learning factual and understanding inferential knowledge, whereas most vocational skills programmes such as auto mechanics and robotics, for example, are hands-on procedural knowledge.Therefore, it is obvious that we cannot directly transfer the research results of using IVR in general education to vocational education. In recent years, only Widiaty et al. (2022) has provided a systematic review of the use of IVR in vocational education, but it only covers empirical articles for the five-year period from 2015 to 2020.The accelerated technological advancement in the field of IVR in recent years is bound to lead to more applications in vocational education.In addition, the review articles on the application of IVR in vocational education only provide a brief list of the methods and results of the studies, and there are no articles that summarise the applications and advantages and disadvantages.

Research Objective

Based on the research gaps mentioned above, the objective of this SLR is to comprehensively sort out the empirical research literature on IVR in vocational education during the period from 2021 to 2025 you, to identify the research gaps, and to provide directional guidance for subsequent empirical research.

Research Questions

RQ1: How is IVR used in teaching and learning in vocational schools?
RQ2: What are the advantages of using IVR in vocational schools?
RQ3: What are the challenges of using IVR in vocational schools?

Methodology

Based on the above research questions, the research methodology of this systematic literature review was implemented in strict accordance with PRISMA standards.The study identified relevant literature from two databases, Scopus and WoS, by searching, screening, and evaluating.After obtaining all the literature that was included, the researcher analyzed the literature comprehensively to understand the applications, strengths and challenges of IVR in vocational education.The research process of this study consisted of six steps: planning, literature search, assessing literature quality, extracting data, integrating data, and writing a review to ensure the rigour of the research process and the reliability of the findings.

Article Selection Process

PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) is a statement for standardizing the reporting of systematic reviews and meta-analyses (Tugwell & Tovey 2021), and is now very widely used for systematic literature reviews. Under this statement, the process of searching for articles becomes transparent and clear, resulting in higher reliability of research results.The article screening process strictly adheres to PIRSMA, and the whole process is divided into three stages, namely identification, screening, and including, as shown in Figure 1. The process of article screening is based on the PIRSMA statement and the flowchart drawn was adapted from the official PRISMA website document.

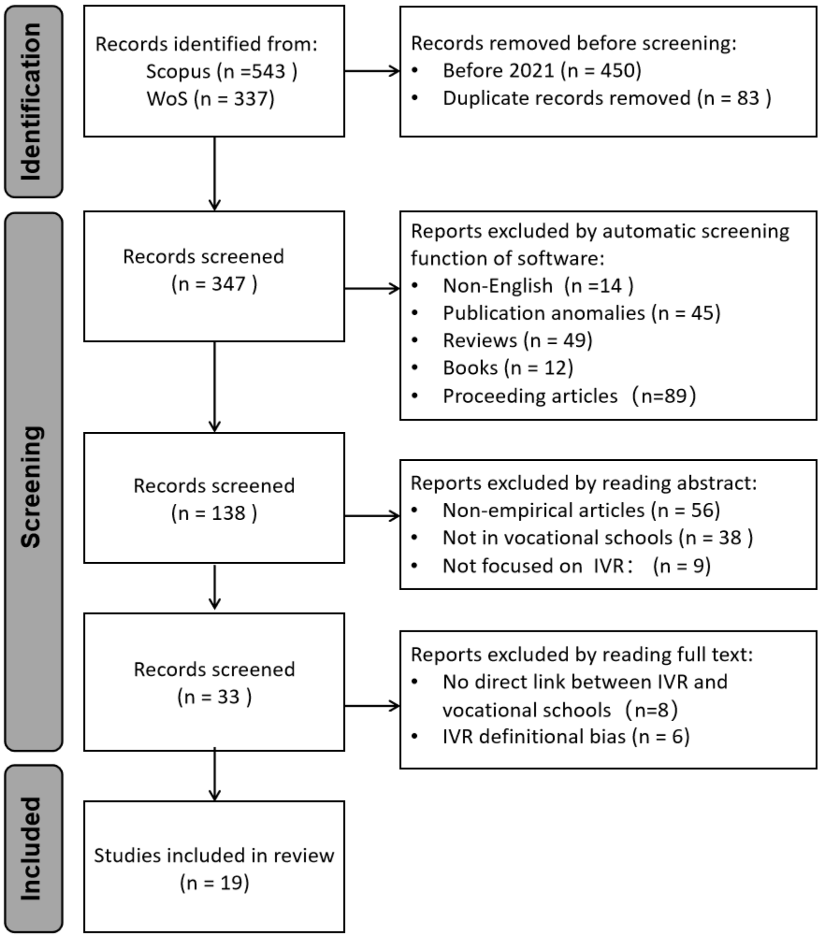

Figure 1 article selection process

Phrase1: Identification

In this study, two databases were chosen as resources for screening the literature, namely Scopus and WoS. The reason for this is that both databases have stringent journal selection criteria, and the journals included are of high quality and high academic impact, which ensures the standard of the articles as well as the reliability of the content in the articles.In addition, both databases have gained international recognition, and many systematic reviews have chosen these databases as their sources of literature.

The researcher rigorously selected keywords to ensure that the most relevant articles on the topic were found as accurately as possible.After selecting the databases, the researcher searched the literature using "Immersive Virtual Reality" and "Vocational School" as well as their synonyms and abbreviations as keywords.The detailed search formula is shown in Table 1. After the first stage of literature search, the researcher found 543 articles in Scopus database and 337 articles in WoS, totally 880 articles.

With the help of the official database website as well as the automated screening function of the software, the year of publication of the literature was further determined in this study at the identification stage to be within five years, i.e., between 2021 and 2025.A total of 450 articles were published before 2021.In addition, the researcher also used an automated tool to remove the duplicate articles and finally 347 articles were entered into the Screening phase.

Table 1
Database and Search Formula

Database	Search Formula
Scopus	(TITLE-ABS-KEY("IVR" OR "Immersive Virtual Reality" OR "Virtual Reality") AND TITLE-ABS-KEY("Vocational School" OR "Vocational Secondary School" OR "Vocational"))
WoS	TS=("IVR" OR "Immersive Virtual Reality" OR "Virtual Reality") AND TS=("Vocational School" OR "Vocational Secondary School" OR "Vocational")

Phrase2: Screening

As shown in Table 2, this study will screen the articles based on the following criteria.Firstly, the researcher uses software with automatic screening function to screen out the articles that do not meet the requirements in the indicators such as language, article type and publication type. Secondly,by reading the article titles and abstracts, the non-conforming ones in the obvious criteria such as scope of research and nature of research will be screened out.Finally, by reading the full text, the articles that best fit this total were included in the study.

Table 2
Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
The focus of the article	Immersive Virtual Reality in Vocational Schools	Articles those are not focus on Vocational Schools or Immersive Virtual Reality
Publication date	From 2021 to 2025	<2021
Publication type	Journal	Book、Proceeding
Article Type	Empirical Article	Review、Concept Paper、Conceptual article
Language	English	Other languages

In the screening stage, the title, author, publication year and other information of all articles were firstly consolidated into a table file, and then the automatic screening function was used to screen the information of all articles.In order to facilitate subsequent reading, non-English articles (n=14) were excluded first, and then articles with abnormal publication status (n=45) were excluded, such as articles with publication status "withdrawn" or other non-"final" status.The following articles were excluded from the list of articles with unusual publication status (n=45).Categories such as reviews (n=49), conference articles (n=89), books and chapters in books (n=12) were also excluded at this stage.There were 138 articles remaining after the initial screening.

The titles and abstract texts of all these 138 documents were exported, and the titles and abstracts were read to screen out articles whose content clearly did not meet the research criteria.Firstly, articles that were not empirical research (n=56) were excluded, such as conceptual articles, articles about software design for IVR, etc.Secondly, articles that were not specific to the use of IVR in vocational education were also excluded (n=38) .For example, some articles referred to vocational training for employees in companies, while others discussed job search training for special groups such as people with disabilities.Finally, articles where the focus of the study was not IVR were excluded (n=9).A total of 33 articles remain after this round of screening.

All 33 full-text documents were downloaded and read in their entirety.Articles that did not focus on the association between IVR and vocational education (n=8) were excluded, as well as some articles with biased definitions of IVR (n=6).

Phrase3: Including

A total of 19 articles were eventually included and the researcher felt that these met the criteria and purpose of the study, as shown in table3.These were empirical articles published within the last 5 years, which were of high quality and current and may apply new techniques and methods of IVR to vocational education.The articles are from different countries and regions and cover two different vocational education segments, secondary and tertiary, as well as different majors.

Table 3
Summary of Included Studies

No.	Authors	Year	Publication	Doi	Region
1	Lee et al.	2023	Interactive Learning Environments	10.1080/10494820.2020.1841799	Chinese Taiwan
2	Hekele et al.	2022	British Journal of Educational Technology	10.1111/bjet.13162	Spain
3	Chen & Liao	2022	Journal of Educational Computing Research	10.1177/0735633121999851	Chinese Taiwan
4	Kitapcioglu et al.	2024	JMIR Serious Games	10.2196/58654	Turkey
5	Saad et al.	2024	Journal of Infrastructure, Policy and Development	10.24294/jipd.v8i8.5662	Malaysia
6	Zhang et al.	2023	Educational Technology Research and Development	10.1007/s11423-023-10313-1	China
7	Ismara et al.	2024	IEEE Access	10.1109/ACCESS.2024.3447589	Indonesia

8	Rafiq et al.	2022	Waikato Journal of Education	10.15663/wje.v27i3.964	Indonesia
9	Keller et al.	2025	Education and Information Technologies	10.1007/s10639-025-13320-2	Switzerland
10	Thomann et al.	2024	Computers & Education	10.1016/j.compedu.2024.105127	German
11	Kablitz et al.	2023	Empirical Research in Vocational Education and Training	10.1186/s40461-023-00148-8	German
12	Kolarik et al.	2023	ADCAIJ: Advances in Distributed Computing and Artificial Intelligence Journal	10.14201/adcaij.31134	German
13	Soenarto et al.	2024	Journal of Advanced Research in Applied Sciences and Engineering Technology	10.37934/araset.31.2.157172	Indonesia
14	Spangenberger et al.	2024	Educational technology research and development	10.1007/s11423-024-10409-2	German
15	Dobricki et al.	2021	Research in Learning Technology	10.25304/rlt.v29.2453	Switzerland
16	Sindu & Kertiasih	2024	Conhecimento & Diversidade	10.18316/rcd.v16i43.11808	Indonesia
17	Saklangıç & Mertoğlu	2023	JOURNAL OF TECHNICAL EDUCATION AND TRAINING	10.30880/jtet.2023.15.03.003	Turkey
18	Wen et al.	2024	Virtual Reality	10.1007/s10055-024-01012-0	China
19	Mulders et al.	2024	Technology, Knowledge and Learning	10.1007/s10758-022-09630-w	German

Results

Overview of studies included

The research methods chosen for the 19 articles included in the review are shown in Figure 2, with 14 articles opting for quantitative research(Chen & Liao, 2022; Hekele et al., 2022; Keller et al., 2025; Kablitz et al., 2023; Kolarik et al., 2023; Lee, 2023; Saklangic &

Mertoglu, 2023; Soenarto et al., 2023; Spangenberger et al., 2024; Thomann et al., 2024; Wen et al., 2024; Zhang et al., 2024; Kitapcioglu et al., 2024; Sindu & Kertiasih, 2024), 1 article opting for qualitative research (Dobricki et al., 2021), and 4 articles opting for mixed research methods(Ismara et al., 2024; Mulders et al., 2024; Rafiq et al., 2022; Saad et al., 2024).

Vocational schools, as we generally discuss, comprise two segments, namely secondary vocational schools and higher vocational schools.Of all the included articles, a total of three studies were conducted mainly on secondary vocational schools(Chen & Liao, 2022; Soenarto et al., 2023; Zhang et al., 2024), while the rest were on higher vocational schools.

Figure 2 Research Methodology

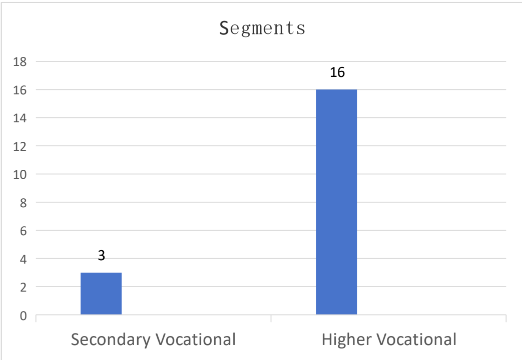

Figure 3 Segments

RQ1: How is IVR used in teaching and learning in vocational schools?

Although there are different ways of presenting IVR, almost all head-mounted displays are used among vocational schools due to the fact that implementations such as Cave are much more expensive.Considering the cost and ease of use of the equipment, it is illustrated that the research on the hardware used for IVR mainly uses brands such as HTC and Oculus (as shown in Figure 4).In addition, in terms of software, except for individual studies that used 360 images, etc. (Hekele et al., 2022; Chen & Liao, 2022), most of the studies used practical training scenarios or serious games built based on Unity for the corresponding professions.

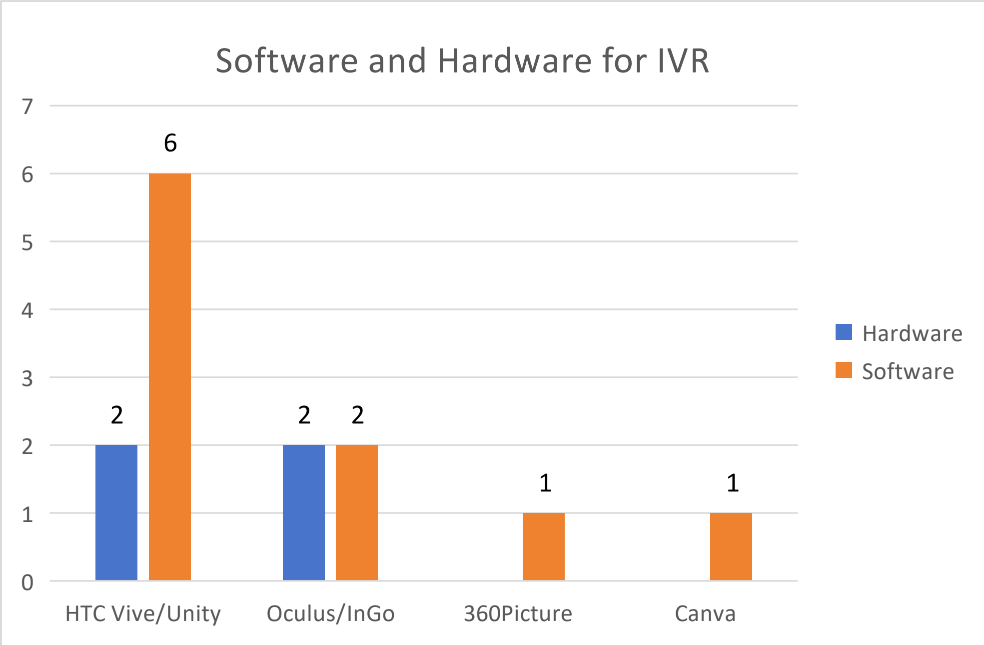

Figure4 Software and Hardware for IVR

Most of the applications of IVR in vocational education are used for practical process simulation in the corresponding professions, while the methods include simulation, immersive scenario learning, and educational games.IVR can be used to allow students to listen to lectures in an immersive scenario in order to have a more realistic observation experience (Kitapcioglu et al., 2024).Moreover, IVR not only allows thestudents to observe, but also allows students to do hands-on exercises in virtual scenarios to complete skills practice, such as assembling computers (Sindu & Kertiasih, 2024).More interestingly, IVR also allows students to become characters in the virtual world and learn skills while completing tasks in educational games (Kitapcioglu et al., 2024; Kolarik et al., 2023; Spangenberger et al.)

Table 4
IVR used in vocational schools

Articles	Application Methods	Application content
Lee, 2023	Simulation	Furniture production process learning
Hekele et al., 2022	360° Video	Automotive Mechanical Training
Chen & Liao, 2022	Panoramic Image	Workplace English Learning
Kitapcioglu et al., 2024	Metaverse VR Training, Serious Games	Anaesthesiology
Saad et al., 2024	VR Safety Education Software	Hotel Safety Education
Zhang et al., 2024	VR Scene	Text trail application

Ismara et al., 2024	Semi-immersive VR	Electrical safety training for heavy equipment
Rafiq et al., 2022	Simulation	Simulation activities
Keller et al., 2025	VR Scene	Virtual Apartment Finding Defects
Thomann et al., 2024	VR Scene	Logistics Expertise Learning
Kablitz et al., 2023	VR Scene	Retail vocational training
Kolarik et al., 2023	VR Educational Games	Cargo Receiving Study in Logistics
Soenarto et al., 2023	Mobile VR Lab	Teaching digital engineering at the secondary level
Spangenberger et al., 2024	VR Serious Games	Troubleshooting Learning for Electrical Professionals
Dobricki et al., 2021	VR Scene	Experiencing, teaching and learning in horticultural work situations
Sindu & Kertiasih, 2024	Simulation	Practical teaching of laptop assembly
Saklangic & Mertoglu, 2023	VR Scene	Fire training, fire safety education
Wen et al., 2024	VR Lab	Digital Camera Course Study
Mulders et al., 2024	Simulation	Car Painting Simulation Training

RQ2: What are the advantages of using IVR in vocational schools?

The advantages of IVR use in vocational school teaching are mainly in four areas: learning effectiveness, learning environment, learning resources, and literacy enhancement.Specifically, there are ten points as follows: a) enhance learning effect, b) enhance immersion, c) promote practical skills development, d) increase learning interest and participation, e) provide a safe learning environment, f) save costs and resources, g) promote active learning and exploration, h) enhance spatial perception, i) improve learning autonomy, and j) promote collaboration and communication, as shown in Table 5.

Aspect one, learning outcomes.Almost most studies have demonstrated that the use of IVR in vocational school curricula enhances student immersion and improves student learning.Some of the articles also point out that IVR can increase student interest and engagement.These factors have been shown to be relevant in other studies.For example, Makransky & Petersen (2021) proposed a model called CAMIL.In CAMIL, Presence and Agency are dependent (positively correlated) variables that promote factors such as motivation, interest in learning, and other factors that are also important in promoting learning outcomes.Students may be more interested and immersed when using IVR for educational games because of the fun nature of the game (Kitapcioglu et al., 2024; Rafiq et al., 2022; Spangenberger et al. 2024).However, Thomann et al. (2024) argued that even though IVR can facilitate learning, its significant effect is not much better than the effect of media such as video.Where IVR can be more effective in vocational education would be in the development of practical skills that are mostly procedural knowledge, such as computer assembly (Sindu & Kertiasih, 2024).

Aspect two, learning environment.In vocational education, it is very important that the teaching content corresponds to actual production scenarios.However, many production scenarios are not conducive to student participation, especially in secondary vocational schools, where some students are still minors. As a result, IVR is able to provide realistic practice environments for majors that are unable to train in the field due to the dangers involved.For example, Ismara et al. (2024) in Indonesia used Unity to create a safety training software in the construction industry where they learnt about dangerous heavy equipment in an IVR.In addition, during the fire safety training, the students agreed that the IVR scenarios were very realistic and were able to recreate real-life scenarios(Saklangıç & Mertoğlu, 2023).

Aspect three, learning resources.Lee's (2023) article points out that IVR applications in vocational education can save costs and resources, for example, the actual production line of furniture requires a large amount of investment and may also produce a very large amount of consumables.Therefore, for those professions where the learning content itself requires expensive facilities and a lot of consumables, applying IVR to their courses is indeed a saving option.

Aspect four, literacy enhancement.It has been suggested that the use of IVR in vocational schools can enhance student literacy, including promoting collaboration, stimulating student autonomy, and so on.For example, research has shown that students are able to increase the frequency of communication with their peers and promote collaborative learning in educational games using IVR (Kolarik et al., 2023).

Table 5
The Advantages of Using Ivr in Vocational Schools

Articles	Learning Outcomes				Learning Environment	Learning Resources	Literacy Enhancement			
	A	B	C	D	E	F	G	H	I	J
Hekele et al.		√								
Chen & Liao	√	√				√				
Kitapcioglu et al.	√	√	√	√						
Saad et al.	√	√	√		√					
Zhang et al.	√	√					√			
Ismara et al.	√	√	√		√					
Rafiq et al.		√		√						
Keller et al.	√	√					√	√		
Thomann et al.	√	√								
Kolarik et al.	√	√							√	√
Soenarto et al.	√	√								√
Spangenberger et al.	√	√	√	√						
Dobricki et al.	√	√								

Sindu & Kertiasih							√	√
Saklangic & Mertoglu	√	√		√	√			
Wen et al.		√						
Kablitz et al.	√	√						
Lee et al.	√	√	√		√	√		
Mulders et al.	√	√	√		√			

RQ3: What are the challenges of using IVR in vocational schools?

Macro level.Zhang et al.'s (2023) article raises a concern that IVR applied to vocational schools can lead to educational inequality.Due to geographic differences, most rural vocational schools are not only unable to purchase costly VR equipment, but also cannot afford those customised software services (Lee et al., 2023).As a result, it is difficult for students to access the same quality of educational design becomes much harder, which requires teachers to have a high level of instructional design skills (Hekele et al., 2022).Not to mention the integration of VR with traditional teaching content, which can become a major problem for teachers (Rafiq et al., 2022).

Student Learning Dimensions.Since head-mounted displays are essentially actually two screens, current technology is not yet able to get their frame rates to a state that is comfortable for everyone, and so it is inevitable that some students will experience motion sickness (Rafiq et al., 2022; Kablitz et al.2023).Among them, a study by Kablitz et al. (2023) reported that about 35.29 per cent of the students had some symptoms of motion sickness.

In addition, six articles all discussed cognitive load(Lee, 2023; Hekele et al., 2022; Zhang et al., 2024; Thomann et al., 2024; Kablitz et al., 2023; Kolarik et al., 2023; Wen et al., 2024; Mulders et al., 2024).Due to the redundancy effect (Mayer, 2014), students may be distracted by non-learning-focused content when using IVR for learning, which can make their learning process more difficult.However, Zhang et al. (2024) noted that although IVR takes up more cognitive resources, it did not impair learning.Mulders et al. (2024) also considered cognitive load to be at an acceptable level.Wen et al. (2024) argued that attention-guiding mechanisms, such as icons like arrows, can be effective in reducing cognitive load if they are introduced in IVRs.When incorporating guidance mechanisms, care should be taken to avoid using too much textual guidance, which may instead increase cognitive load (Zhang et al., 2024).

Discussion

This systematic review among 19 articles concludes that the use of IVR in vocational education can improve student learning.However, combining all the literature, the results are not particularly impressive, especially compared to other media sources such as video.Therefore, IVR in vocational education is designated as an adjunct rather than a complete substitute for other new media.This is consistent with the findings of Wu et al. (2020).One possible explanation is that this is related to the motion sickness and higher cognitive load associated with IVR.In addition, the novelty effect (Miguel et al., 2024) may also contribute to this result.Students may show higher levels of concentration and engagement in the initial stages of learning with IVR, but this concentration declines over time until they lose interest in the novelty, leading to a gradual discounting of learning effects in the second half of the process.However, different ways of applying IVR in vocational education and different learning content can lead to potentially quite different results.Therefore, it is necessary to design different IVR applications for different contents and analyse them empirically.

In addition, challenges encountered by IVR in vocational education include difficulties in instructional design, impediments to student learning, and so on.This result was also seen in previous studies with the same conclusion (Wu et al., 2020; Widiaty & Abdullah, 2022).Instructional design challenges can be addressed by improving the ease of use of IVR devices and software (Liu et al., 2020), which helps teachers to better utilise their instructional design talents.The issue of IVR causing motion sickness needs further attention from developers as well, I think.In addition to working on commercial entertainment features, I think it is every developer's social responsibility to break through the bottleneck of frame rate technology (Recenti et al., 2021), which will help IVR blossom in multiple industries, including education.In addition, policy decision makers should also encourage teachers to work with developers to further explore the detailed content of IVR applications in order to minimise cognitive load generation.

Limitations

This systematic review focuses on the use of IVR in vocational schools within the last five years, and the databases selected are Scopus and WoS. even though both are already recognised as high-quality databases, it is possible to miss good quality empirical articles.In addition, the five-year time limit, while enabling this study to focus more on the most recent findings, does risk missing out on the inclusion of groundbreaking, historical quality research.

Future Research

How IVR affects learning outcomes can be further investigated in different academic disciplines and specialisations to find out exactly how IVR can be used to be significantly more effective than ordinary learning media, rather than just an aid or even a source of high cognitive load.Future research could also focus on how to address the negative aspects of IVR, including but not limited to cognitive load, and use empirical research to see if these issues are addressed in pedagogical innovations.

Conclusion

In this study, 19 articles were selected and included in two databases, Scopus and WoS, to be analysed using the systematic literature review methodology under the PRISMA report.This review summarises how IVR is applied in vocational education, including hardware, software, application content and so on.At the same time, this review summarises the advantages and challenges of IVR in vocational education, which can lead to improved learning outcomes, even if this is sometimes not very obvious, and may cause motion sickness and cognitive load.In addition, IVR can also have a positive impact on indicators such as students' quality improvement and learning engagement.

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