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Abstract
With the ongoing advancement of intelligent information technology, virtual reality (VR) higher education, during this new era of reform, the incorporation of VR technology has led to an evolution of teaching methods. VR technology has been integrated into education and teaching, for example through virtual laboratories, digital environments and simulation-based training, thus providing higher education institutions with diverse teaching approaches and developmental opportunities. This study systematically categorises the utilisation of VR technology in tertiary education through the analysis of two databases, Web of Science (WoS) and Scopus. The systematic review process was conducted by referring to PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) as a guide, and 29 articles were extracted from the 478 articles for the period 2014 to 2023, taking into account exclusion and inclusion criteria. Firstly, the review revealed significant benefits of using VR applications in higher education, which were categorised into three categories. Secondly, the review examined challenges related to the use of VR in higher education content and categorised them into five categories. Overall, this review consolidates research discoveries and pragmatic insights to offer a refined comprehension of the present condition of VR in advanced education. Moreover, it provides recommendations for future development, which holds significant value for the effective use of VR technology in higher education.

Keywords: VR, Virtual Reality, VR technology, Higher Education, Higher Learning

Introduction
VR virtual reality technology encompasses system simulation, sensing, big data network information technology, and graphics, delivering significant practical benefits. When applied to higher education, teaching design, experimental analysis and professional skills training, it plays a crucial supporting and promotional role. According to (Rajendran & Yunus, 2021), the Chinese examination-oriented culture has such serious backwash effects on its learners that they are often characterized as passive consumers rather than. This paper aims to comprehensively analyse and explore the practical application of VR virtual reality technology.
in higher education. It will examine the advantages and characteristics of this technology and make practical attempts to further expand its application within higher education.

The following general questions guided the process of analysing the following literature
Question 1: Benefits of VR Applications in Higher Education?
Question 2: Challenges of using VR in higher education?
By dealing with these questions, this study hopes to support the evolution of teaching and learning strategies and methodologies, and provide insights and recommendations for the use of VR in higher education.

**Characteristics and application status of VR virtual reality technology**
VR technology is primarily founded on computer simulation, artificial intelligence, big data, sensing, and system simulation. Essentially, virtual reality (VR) technology utilizes people's sensory organs such as vision, hearing, and touch, by means of virtual image and sound processing, to create a highly simulated virtual environment that immerses people within it. (De Back & Louwerse, 2020)
Virtual reality technology possesses features of immersion, interactivity, and imagination. The present utilisation of VR technology in higher education is mainly centred around "human-computer interaction" (Albus & Seufert, 2021). In the case of COVID-19, large-scale changes happened overnight to find ways to optimise distance education and virtual learning was emerging and evolving quickly. Educators were forced to adapt to the rapid changes in the education system (Santhanasamy & Yunus, 2022)

**Methods**
The systematic review process was conducted by referring to PRISMA (Preferred Reporting Items for Systematic Review and Meta-Analyses) as a guide. As shown in Figure 1.
Identification

The first step is to select four suitable databases (Web of Science (WoS), Scopus) Table 1 below shows the search strings used for each database in this study.

Table 1

<table>
<thead>
<tr>
<th>Search string</th>
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</thead>
<tbody>
<tr>
<td><strong>Database</strong></td>
</tr>
<tr>
<td>Scopus</td>
</tr>
<tr>
<td>Web of Science</td>
</tr>
</tbody>
</table>
Education" OR "College-Level Education" AND "appliance*" OR "use*" OR "Technical Applications*" AND "benefit*" OR "Advantage*")

*: Search String

2. Screening
The first step was to remove duplicate articles (13 in total) and 465 articles were eligible for further screening. The 465 articles were screened based on title, abstract and keywords with the aim of making them relevant to virtual reality and higher education.

The search results of the selected databases showed that before 2014, relevant articles were very sparse and not clearly oriented, there are not many systematic reviews before 2014. Therefore, 2014 to 2023 was used as one of the inclusion criteria.

Table 2
Screening condition

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Eligibility</th>
<th>Exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timeline</td>
<td>Between 2014 to 2023 (10 years)</td>
<td>&lt;2014</td>
</tr>
<tr>
<td>Literature type</td>
<td>Articles from journals</td>
<td>Systematic reviews, books, chapters in a book, conference proceedings</td>
</tr>
<tr>
<td>Language</td>
<td>English</td>
<td>Non-English</td>
</tr>
<tr>
<td>Scope</td>
<td>Related to Use of VR in Higher Education</td>
<td>Not related to Use of VR in Higher Education</td>
</tr>
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</table>

After careful screening based on inclusion and exclusion criteria, 29 articles were potentially included in this systematic review. Although conference proceedings and book chapters were reviewed, they were excluded because they were not comprehensive enough.

3. Included
The articles reviewed in this systematic review are centred around "Virtual Reality Technology in Higher Education". As shown in Table 3, 16 articles were selected from Scopus and 13 articles from WoS.

The studies aim to explore the use of VR technology in higher education. The research has been primarily conducted in higher education institutions, including colleges and universities [1-29], with a focus on utilising VR for classroom instruction [1,3,5-8,11,12,17-29] and simulation experimentation [2,4,9,10,13-16,21-25].
<table>
<thead>
<tr>
<th>Study</th>
<th>Database</th>
<th>Aim</th>
<th>Samples</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>de Back, T. T., Tinga, A. M., Nguyen, P., &amp; Louwerse, M. M. (2020).</td>
<td>Scopus</td>
<td>The current study evaluated whether academic learning using a cutting-edge CAVE resulted in greater learning gains than traditional textbooks.</td>
<td>Learners at school</td>
<td>The results showed that collaborative learning in the CAVE resulted in much better learning gains with large effect sizes. Furthermore, the study shows how immersive learning might give unique scaffolding to improve performance in individuals who need it the most.</td>
</tr>
<tr>
<td>Al-Khiami, M. Scopus, I., &amp; Jaeger, M. (2023).</td>
<td></td>
<td>The purpose of this research is to look into the applicability of a specific safety training module linked to &quot;Working at Heights&quot; for workers</td>
<td>VR module users</td>
<td>The data show that workers exposed to the VR technique have a statistically insignificantly higher learning effectiveness.</td>
</tr>
<tr>
<td>Issleib, M., Scopus Kromer, A., Pinnschmidt, H. O., Süß-Havemann, C., &amp; Kubitz, J. C. (2021).</td>
<td></td>
<td>Virtual reality is a cutting-edge tool for medical education with a high level of empirical realism. As a result, this study compares traditional CPR training to Virtual Reality (VR) instruction</td>
<td>104 first-year undergraduates</td>
<td>In terms of imparting technical skills, a &quot;classic&quot; BLS-course with a seminar and training appears to be preferable to VR. However, the overall learning gain with VR was greater. VR integration should be considered in future BLS course forms.</td>
</tr>
<tr>
<td>Soto, J. H. B., Scopus Ocampo, D. C. T., del Carmen Beltrán Colón, L., &amp; Oropesa, A. v. (2020).</td>
<td></td>
<td>The main aim of the project is to analyse the impact of using the virtual reality platform ImmersedMe as an empowering and innovative tool for learning English in private institutions</td>
<td>Private university 1st-3rd year students</td>
<td>The study's conclusions demonstrated that an immersive virtual reality platform such as this one is perfect for improving the various aspects of EFL from an immersive focus while taking into account various contexts</td>
</tr>
<tr>
<td>Caño de las Heras, S., Gargalo, C. L., Caccavale, F., Kensington-Miller, B., Gernaey, K. v, Baroutian, S., &amp; Krühne, U. (2022).</td>
<td>Semi-structured interviews, surveys, casual talks between the students and the developer, and other methods have been used in two different colleges to gather both qualitative and quantitative data.</td>
<td>Students in higher education It was discovered that the viewpoints of the students offered insightful criticism regarding the functionality, usability, and content of the platform. Opinions were gathered and carefully evaluated, such as suggestions to modify the platform name or include coding exercises linked to bioprocesses.</td>
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<tr>
<td>Paszkiewicz, A., Salach, M., Dymora, P., Bolanowski, M., Budzik, G., &amp; Kubiak, P. (2021).</td>
<td>This essay offers a completely novel strategy for integrating virtual reality (VR) into the classroom. It is predicated on the extensive methodology that has been suggested, which covers the planning, development, execution, and assessment of specific courses that are used in virtual reality. The new methodology's comprehensiveness and universality are crucial features.</td>
<td>Participants trained in the virtual environment It can be used in numerous fields, including higher education, shipbuilding, aviation, automobile, and energy. The study also lists the notable benefits and drawbacks of VR-based learning, which could affect the field and type of applications for it. Furthermore, a virtual reality training station model has been created based on the suggested methodology.</td>
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<tr>
<td>Li, G. (2022).</td>
<td>This study examines the current state of higher education through a questionnaire survey, and it analyses the benefits, issues that still need to be resolved, and potential uses of virtual reality and student of a university or college The findings demonstrate that virtual reality and wireless communication technologies improve teacher quality of instruction as well as students' experiences and motivation. This offers a crucial point of</td>
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wireless communication technologies in the context of college education reform. This essay covers the main virtual reality technologies, presents the pertinent theoretical underpinnings, and lists the benefits and drawbacks of the most widely used virtual reality devices at the moment.

Vocational university students


Constructivism and variant learning theory have been effectively applied in engineering education, and there is sufficient evidence to support their applicability in virtual reality teaching.

In this work, we make the case and provide evidence from a large body of research that virtual reality is a great teaching tool for engineering. By using VR in place of actual laboratories, the university or institution can also benefit from lower responsibility, infrastructure costs, and expenses. Equal educational opportunities also benefit students with special needs and distance learners who may not have access to physical laboratories.

Perceived enabling conditions, perceived effort anticipation, and perceived compatibility were found to have a substantial impact on the intention to use VR systems and tools for education, according to the results. We think it is now crucial to take steps to raise the standard of vocational education and the calibre of instruction in order to prepare for the next wave of industrial and technological development.

They looked into what influences higher education institutions' adoption of virtual reality. To do this, we developed a set of assumptions and added four new elements to the technology reference for reforming higher education.
Acceptance Model (TAM). Next, utilising a dataset gathered from 503 Jordanian students, the hypotheses are assessed. The theoretical section looks into the elements of the traditional educational system in industry and education.

Through the use of 27 questions, three hypotheses about the use of VR technology, as well as the efficacy, immersion, and user impact of the VR system, were tested. The results showed that the VR system is advantageous to the user in improving immersion and assisting students in learning.

Examining the advantages, satisfaction, and constraints of intergenerational contacts brought about by the use of virtual tools was the goal of this study. The majority of individuals who took part in virtual interactions between generations mentioned how their social interactions, relationships, emotions, mental health, and academic education all improved.

This study aims to assess students' adoption of learning objects created in 360° and virtual reality, as well as examine their assessment and the relationships that have been developed. High levels of acceptance are seen in the results for 360° and VR objects. With strong relationships found among the various characteristics, the students thought the training exercise was very beneficial. This work opens up new avenues for future research and shows how VR may be used as an instructional tool.
Bartels, N., & Scopus Hahne, K. (2023). How instructors and students felt about a 360° prototype video that they had viewed in virtual reality goggles while an educational project was still in the planning stages. The participants shared the opinion that students might be better prepared for real-world practice in social work and health care by using the virtual reality educational tool.

Lie, S. S., Scopus Røykenes, K., Sæheim, A., & Groven, K. S. (2023). This paper discusses the effect of digital design and construction teaching using virtual world as a teaching tool. Civil engineering students

Ogrizović, D., Scopus Hadžić, A.P., Jardas, M. (2021). In a discrete-event simulation of logistics operations, this article examined users' impressions of the possible application of fully immersive virtual reality head-mounted displays. Users of fully immersive virtual reality head-mounted displays

Antonopoulou Wosu, A., & Dare, E. (2022). Enhanced monitoring through "artificial intelligence" transaction data and student debt analysis. The authors agree that knowledge is not beautiful; rather, it is an illusion of stability that serves a neoliberal, anti-academic, and rapacious worldview that should be exposed and given frank discussion, free from managerial wishful thinking and hype. It is impossible to portray truth and beauty as
steady, uniform, or global as doing so would be akin to colonial knowledge projection and mono-logic that centres all truth on the Global North.

In dentistry, VR/AR is a helpful supplement to traditional education. But there are obstacles standing in the way of VR/AR's broad adoption and uses, like a dearth of trials, a lack of standards, and certification issues with equipment and content.

This technology is becoming more useful in training and educational settings as it gets more accessible, immersive, and user-friendly.

Research indicates that when given the right tools—a combination of synchronous and asynchronous learning—engineers without any programming experience may learn VATS.
activities, and deliverables involved in the process was proposed.


This article reports an additional course in real-time interactive molecular dynamics simulations utilizing virtual reality (iMD-VR). study

Most students found that iMD-VR components stimulated their interest in computers more than traditional methods.


The current work includes a thorough intrinsic case study that describes the steps and important factors that influenced the choice of appropriate instructional materials, software development, hardware fixes, and implementation. The decision-making process, components deemed useful, obstacles encountered, and key takeaways are described in detail.

Organisations and individuals looking to create procedures and pathways to incorporate XR technology may find these insights helpful, especially when it comes to enhancing their current training and educational programmes.


We talk about our experiences with the workshops and the potential that comparable VR game platforms have for studying design cognition in general and ideation, prototyping, issue reframing, intrinsic motivation, and

The VR gaming platform provides a foundation for training interventions in design education and practice, in addition to being a great complement to current research alternatives.
<table>
<thead>
<tr>
<th>Authors</th>
<th>Title</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Udeozor, C., Toyoda, R., Abegao, F. R., &amp; Glassey, J. (2021).</td>
<td>How chemical engineering professionals and students view the usage of VR games for health and safety training and teaching. The study also explores the practical consequences of its results.</td>
<td>According to the survey, both professionals and students think that IVR games can help with learning. Professionals were shown to be more receptive to technology than students when the two groups were compared.</td>
</tr>
<tr>
<td>Garcia-Bonete, M. J., Jensen, M., &amp; Katona, G. (2019).</td>
<td>Teachers of structural biology who lack extensive expertise of information technology can benefit from this guide.</td>
<td>Although specialised laboratories have long employed VR, AR techniques, it is only recently that these technologies have become more widely available and inexpensive for consumers. The benefits of practicing in front of a virtual audience a third time were evident from the results. Participants who were nervous and those who weren't made equivalent progress in their presentation abilities and VR intervention experiences. The ideal quantity of practice presentations, however, is still up for debate and needs more research.</td>
</tr>
<tr>
<td>Boetje, J., &amp; van Ginkel, S. (2021).</td>
<td>Using a pre-test post-test methodology, this experimental field study investigated the potential benefits of an additional VR practice session on the advancement of 35 graduate students in OPS.</td>
<td>The goal of this project is to support CT knowledge by creating and deploying iThinkSmart, a virtual University of Nigeria Computer Science students (47) Results point to an increase in students' enthusiasm and, consequently, in their CT skills. These findings add to our</td>
</tr>
<tr>
<td>Agbo, F. J., Oyelere, S. S., Suhonen, J., &amp; Tukiainen, M. (2022).</td>
<td>The goal of this project is to support CT knowledge by creating and deploying iThinkSmart, a virtual University of Nigeria Computer Science students (47) Results point to an increase in students' enthusiasm and, consequently, in their CT skills. These findings add to our</td>
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<td>The study looked at how children, ages 12 to 13, learned important ideas in nanoscale cell biology when they added haptic input to a 3D virtual reality (VR) simulation.</td>
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<tr>
<td>Students (N = 64), in two secondary schools Pre- and post-test results on conceptual knowledge revealed considerable knowledge gains; however, the addition of haptic input had no discernible impact on the knowledge gains. The research made it possible to identify crucial factors to take into account while creating and utilising haptic-enabled 3D virtual reality settings for group education.</td>
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</table>

4. Data Analysis Procedure

All selected articles are exported to the reference software Mendeley. matic analysis was performed. research questions:

Question 1: Benefits of VR Applications in Higher Education?

Question 2: Challenges of using VR in higher education?

This review provides an interpretative analysis of the articles and categorises the topics in response to the re-search question

According to the first research question, the advantageous features that VR technology has in higher education were classified into three categories. For the Question 2, the challenges of VR technology in higher education mentioned in the article are explained in five sections, according to which the difficulties encountered in the current use of VR technology in higher education classes and experiments are analysed.

Results

1 Question 1: Benefits of VR Applications in Higher Education?

In this systematic review, VR technology has the following three advantageous features in higher education
Table 4
Benefits of VR Applications in Higher Education

<table>
<thead>
<tr>
<th>Type</th>
<th>Related articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immersion</td>
<td>[1-10,25,27,28]</td>
</tr>
<tr>
<td>Interaction</td>
<td>[4,7,9,10,15-24,27]</td>
</tr>
<tr>
<td>Conceptualisation</td>
<td>[3,11,12,16,17,29]</td>
</tr>
</tbody>
</table>

(i) Immersion
According to literature sources [1-10,25,27,28], VR relies on the physiological and psychological properties of human vision and hearing. The process involves the use of computers to produce authentic three-dimensional stereoscopic images. The virtual environment elicits a sense of realism, and users feel completely immersed. [1,3,8] greatly improves students' motivation to learn. [1,2,5-10,25,27,28]

(ii) Interaction
Various studies [4,7,9,10,15-24,27] have noted that human-computer interaction in VR virtual reality systems is close to a natural experience. This means that users are able to interact with the system not only through conventional means such as a keyboard and mouse, but also through specialized sensing devices such as helmets and gloves that respond to hand, head, speech, eye, and body movements. Asynchronous teaching can be made possible by this technology, which can be tailored to meet the individual needs of students. [7,10,15,27]

(iii) Conceptualisation
In the literature [3,11,12,16,17,29], it is said that VR is a design tool in addition to a medium for presentations. It is a visual representation of the designer's concepts; virtual reality has the ability to transform this notion into tangible virtual worlds and products, whereas traditional sand table design was the only option available in the past. Improve to the ideal state of digital technology, resulting in a significant increase in the effectiveness and calibre of planning and design. [3,11,12,29]

2 Question 2: Challenges of using VR in higher education?
In this systematic review, VR technology in higher education has the following five challenges
Table 5

<table>
<thead>
<tr>
<th>Type</th>
<th>Related articles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited space for practical training and</td>
<td>[6,13,28]</td>
</tr>
<tr>
<td>teaching</td>
<td></td>
</tr>
<tr>
<td>the high price of practical training equipment</td>
<td>[2,29]</td>
</tr>
<tr>
<td>the updating speed of the equipment cannot</td>
<td>[2,9-13,29]</td>
</tr>
<tr>
<td>keep up with the rapid development of science</td>
<td></td>
</tr>
<tr>
<td>and technology</td>
<td></td>
</tr>
<tr>
<td>the danger of operating the equipment</td>
<td>[2,4]</td>
</tr>
<tr>
<td>Insufficient investment in experimental teaching</td>
<td>[3-5,12-16]</td>
</tr>
</tbody>
</table>

First, the limited space for practical training and teaching, as well as the excessive size of the practical training equipment, leads to the fact that only students in the vicinity of the equipment can observe the whole process of the teacher's operation of the equipment in close proximity, while other students can only look at the whole practical training process and lack a comprehensive understanding. [6,13,28]

Second, the price of practical training equipment remains high, which makes it very difficult to solve the financial problems of equipment configuration. At the same time, the complex structure of the equipment requires specialised personnel to operate, manage and maintain it, which brings additional high expenses. [2,29]

Thirdly, The high cost of practical training equipment means that equipment updates too slowly to keep up with the speed at which science and technology are developing. Schools must spend a lot of money to keep its equipment up to date with technology, and upgrading the outdated equipment will be a huge waste of funds. [2,9-13,29]

Fourthly, for students who lack practical experience, it is dangerous to operate the equipment. Usually, the teaching process is based on the teacher's demonstration, and students can only simply imitate and lack the opportunity to explore on their own, thus reducing the effectiveness of the experiment. [2,4]

Fifthly, some majors of liberal arts nature have not invested enough in experimental teaching, for example, finance and management majors are more inclined to teach mainly language, with relatively few experimental opportunities. As for students majoring in tourism, experiments usually require field trips, but the high cost has become an important factor restricting students' participation in practical activities. [3-5,12-16]

Discussion

The results of the study highlight the use of VR technology in higher education, and in general, the findings suggest that the use of VR technology contributes to higher education. The benefits include: (i) Immersion; (ii) Interactivity; (iii) Conceptualisation

It is likely that VR technology will be used on a larger scale in higher education in the future, linking VR technology and higher education more closely. Innovate the methods, actively introduce, apply VR technology to improve the teaching ability of education and provide the most convenient way to cultivate talents.
Next, this review also explores Challenges of using VR in higher education, the reasons are summarised into five points, including: (i) Limited space for practical training and teaching; (ii) the high price of practical training equipment; (iii) the updating speed of the equipment cannot keep up with the rapid development of science and technology; (iv) the danger of operating the equipment; (v) Insufficient investment in experimental teaching.

The first and second reasons are the problems faced by most of the higher education schools, and the updating of funds and technology is also the focus and difficulty of using VR technology in higher education.

With the ubiquitous nature of social media, many educators are coming to see this technology as an avenue to make learning more accessible to their students. (John & Yunus, 2021) Applying VR technology to actual teaching has high requirements for capital investment, technology, equipment and teachers. Whether it is the pressure of capital, technology or teaching, these are the great challenges and difficulties encountered in the actual application of VR technology, which need to be constantly practiced and explored.

Conclusions

This paper reviews the literature on the application of VR technology in higher education. Thus, to support the evolution of teaching strategies and methods, and to provide insights and recommendations for the use of VR in higher education, filling the gap left by the lack of a comprehensive review of VR and higher education. Two databases, web of Science (Wos) and scopus, were used in this review, which included 29 articles.

Question 1: Benefits of VR Applications in Higher Education
(i) Immersion; (ii) Interactivity; (iii) Conceptualisation

Virtual environments can create a sense of reality, and users are fully immersed in them, greatly improving students' motivation to learn. The human-computer interaction in VR virtual reality system is close to the natural experience. This technology makes asynchronous instruction possible and can be tailored to the individual needs of students. At the same time, VR is a design tool and a display medium that improves to the ideal state of digital technology, thus significantly improving the efficiency and level of planning and design.

Question 2: Challenges of using virtual reality in higher education
(i) Limited space for practical training and teaching; (ii) the high price of practical training equipment; (iii) the updating speed of the equipment cannot keep up with the rapid development of science and technology; (iv) the danger of operating the equipment; (v) Insufficient investment in experimental teaching.

Through the above two questions, this paper comprehensively analyzes and discusses the practical application of VR virtual reality technology in higher education. Study the advantages and characteristics of VR technology, and make practical attempts to further expand its application in higher education, and realize the goal and pursuit of applying VR technology in college classrooms faster and better.

According to the findings of this review, there are more opportunities for the application of virtual reality technology in higher education. There are several restrictions on this study. There is no mention of education level as a trend in this study because the majority of studies on the use of VR technology in higher education have concentrated on undergraduate students at universities and colleges. This restriction undoubtedly creates new avenues for investigation in the future, particularly with
regard to the selection of several study tiers about the application of VR technology in higher education. Second, Web of Science and Scopus are reputable journals from which the papers in this review are drawn. As a result, if additional databases like Google Scholar and Science Direct are employed, the outcomes could alter slightly. Notwithstanding its shortcomings, this systematic review contributes significantly to the body of knowledge about VR technology in higher education, helping practitioners in related domains and opening up new avenues for investigation. In order to fully realise the application and development of VR technology in higher education, this review also closes any gaps about the advantages and disadvantages of the technology.

References


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