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Exploring the Factors Influencing the Adoption of Virtual Reality and Augmented Reality in Education

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Abstract

The world has stepped into a new era, an era of information and revolutionary technologies. The fourth industrial revolution, as it is better known, is affecting mankind's way of life in terms of communication, work, and learning systems. Virtual reality (VR) and augmented reality (AR) are some of the game changing technologies offering virtual activities with real-world experiences. The two complementary technologies have become promising tools in the field of education as they contribute better to Education 4.0. Education is an enabler and is regarded as a critical component in the uplifting of lives the world over. There is a great need for changes and reforms to effectively improve the quality of education. This paper aims to explore the factors that influence the adoption of VR and AR in education. A systematic review was conducted by searching four databases published in 2020. Nineteen (19) articles met the final inclusion criteria. The findings reveal that the factors influencing adoption of VR and AR are ease of use, immersion, perceived ease of use, performance expectancy, and effort expectancy, while the opportunities presented are collaboration, immersion learning, increased creativity and innovation, and remote learning. Drawing from these findings, this study developed a conceptual framework that can act as a guide for educational practitioners, school heads, and education policymakers when adopting these transformative technologies.

Keywords
Virtual Reality, VR, Augmented, AR, Reality, Education

1. Introduction

The incorporation of virtual reality (VR) and augmented reality (AR) technologies in education has garnered significant attention due to their potential to create immersive and interactive learning experiences against the traditional learning system, which often emphasizes passive learning, focusing on memorization and rote learning (Negi 2024). By adopting these simulation technologies that mimic real-world scenarios and real-life objects, VR and AR provide experimental learning opportunities that fulfil the United Nations strategic development goal (SDG) number 4, which stresses quality education. According to (Wetzstein 2020), VR and AR are projected to grow by 29.6% between 2023 and 2028 in its Augmented and Virtual Reality in Education market report published in July 2023. This technology is offered through simulation software applications on an array of devices like Google, smartphones, tablets, and many other forms (Di Natale *et al.* 2024) (Murala 2024)(da Silva *et al.* 2019). These technologies have been around for some time now, and their adoption has been mainly focused on the design and development of VR and AR systems (da Silva *et al.* 2019) (Kurniawan, no date) (Fokides and Antonopoulos 2024)In the educational field, this is still an emerging technology due to its exciting immersive effects, which are engaging and expressive. However, despite their potential in enhancing student learning outcomes in education (Noble Saville and Foster 2022) (Ndlovu *et al.* 2022)they have faced serious challenges, including prohibitive costs, technological complexities, and resistance to change by educators, amongst many others (Pan *et al.* 2021)(Hajirasouli and Banihashemi 2022)(Kavanagh *et al.* 2017)((Ndlovu *et al.* 2022)Additionally, concerns about the pedagogical effectiveness of VR and AR and the lack of robust evidence supporting their impact on learning outcomes contribute to hesitancy among educational institutions to invest in

VR and AR technologies (Doerner and Horst 2022)(Noble, Saville and Foster 2022). There is a pressing need for comprehensive research to identify these barriers and explore strategies to overcome them, thereby facilitating the integration of VR and AR into mainstream educational practices for the exposure of their many benefits to institutions, educators, and learners. It is against this backdrop that research delves into the literature to investigate the factors influencing the adoption of VR and AR in education. To do this, the following research questions were formulated:

Research Questions

- What are the key factors influencing the adoption of AR/VR technology in education?
- What are the benefits of AR/VR technology in enhancing educational experiences?
- What are the barriers hindering the adoption and effective utilization of AR/VR technology in educational settings?

2. Methodology

This study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Rethlefsen and Page 2022)facilitating the identification of potentially relevant articles.

2.1 Identification and Search Criteria

The electronic databases searched were IEEE, Springer, Scopus, and ScienceDirect. The search strategy used was "virtual reality" (VR) AND "augmented reality" (AR) AND (education or learning. The inclusion criteria were peer reviewed articles and journal papers that focus on virtual reality and augmented reality, X or extended reality, the metaverse, mixed reality in education, as well as studies published in peer-reviewed articles in English. These papers were from 2020 to 2024. The exclusion criteria were VR and AR applied in other fields besides education. The search yielded 9 papers from IEEE, 5 from Scopus, 3 from ScienceDirect, and 6 from Springer.

2.2 Screening and Eligibility

From a total of 1523 papers, 342 duplicates were removed, while 843 were eliminated on the basis of the title not meeting the research focus, remaining with 338. From the 338 papers, the abstracts were read, 188 papers were removed, and 150 remained. After a full-text review process, 131 papers were eliminated, and 19 were finally identified for inclusion. A total of 19 studies met the final inclusion criteria (Figure 1).

3. Results

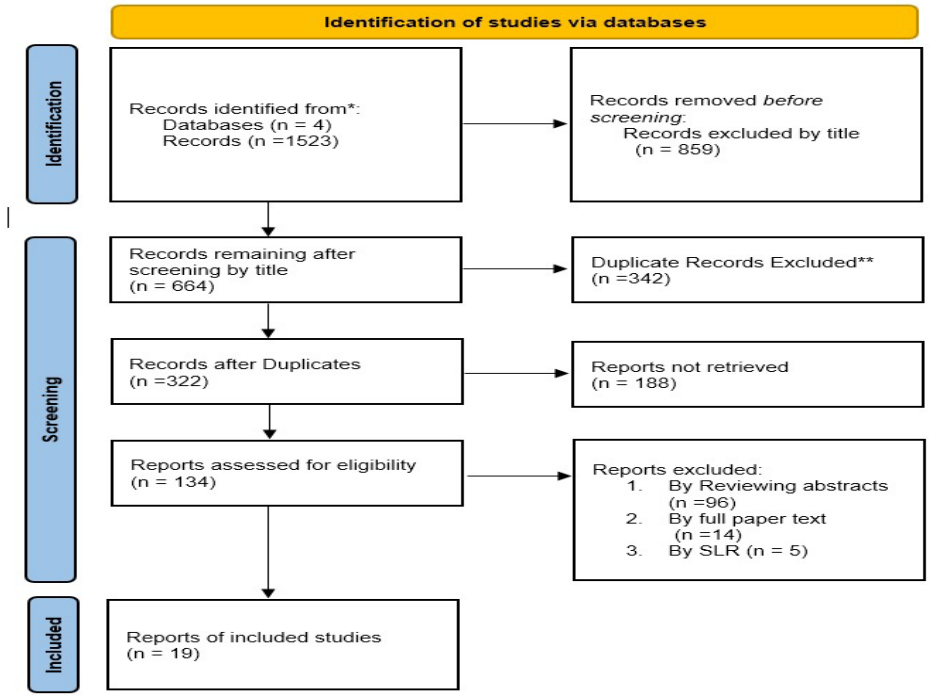

Figure 1. PRISMA flow diagram detailing the selection process.

Table 1 Publications and citation Trend.

Author	Country	Author	Country	Methodology	Theoretical Framework	Factors	Benefits
((Di Natale *et al.* 2024)	Italy	(Di Natale et al. 2024)	Italy	Mixed methods	Extended Expectation-Confirmation Model (EECM)	• perceived usefulness • perceived ease of use • self-efficacy • performance expectancy • effort expectancy	• improvements in learning productivity and academic performance
(Fokides and Antonopoulos 2024)	Greece	(Fokides& Antonopoulos 2024)	Greece	qualitative	TAM n UTAUT	• Immersion • Perceived ease of use • Motivation • Perceived knowledge gain	• Motivation • knowledge gains
(Álvarez *et al.* 2024)	Spain	(Álvarez et al. 2024)	Spain	Mixed methods	TAM	• Perceive usefulness • Perceive ease of use • Attitude • Behavioural intention	• Enjoyment, and Confidence. • Immersion and interaction
(Negi 2024)	India	(Negi 2024)	India	Qualitative	TAM	Efficacy effectiveness	• immersive • engaging learning experiences • student engagement • attitude transformation
(Tan 2024)	Vietnam	(Tan et al. 2024)	Vietnam	Mixed method		Learner experience Multiple goals	• Immersive experience • Entertainment experience • Convenience experience • multisensory experience

							• usage experience
(Hoai *et al.* 2024)	Vietnam	(Hoai et al. 2024)	Vietnam	Mixed methods		• Career and academic qualifications • English proficiency of teachers • Internet infrastructure	• bridge the gap between theoretical knowledge and real-world application, • enhance conceptual understanding • improve information presentation in 3D and 4D interactive experiences • facilitate practical learning.
(Cárdenas-Sainz *et al.* 2023)	Mexico	(Cárdenas-Sainz et al. 2023)	Mexico	QUALITATIVE		• accessibility • portability • ease of use • familiarity • mobility • comfort • Perceived satisfaction	• Improvement on students' learning gains. • motivation
(Ndlovu, Maphosa and Dube 2023)		(Ndlovu et al. 2023)			Build methodology		• remote access
(Putranda *et al.* 2023)	Indonesia	Putranda *et al.*, 2023)	Indonesia	Mixed method	TAM	• ease of use • curiosity • perceived usefulness • behave intention to use • control • joy	• score gains • motivate
(Zhang, Zhou and Zhao2023)	China	((Zhang, Zhou and Zhao, 2023)	China	qualitative		• impact • intuitive • space • operation	• Cultivates innovative thinking • Increase in grades

(Al-Oudat& Altamimi 2022)	Jordan (Asia)	(Al-Oudat& Altamimi 2022)	Jordan (Asia)	Quantitative	TAM		
(Doerner and Horst, 2022)	Germany	(Doerner & Horst 2022)	Germany	qualitative		Prior knowledge and experience of VR and AR	• Increased learner motivation • Increased creativity
(Dutta, Mantri and Singh 2022)	India	(Dutta et al. 2022)	India	Quantitative	TAM	• Ease of use • Task match • Ease of learning	• Increase attention span • motivation
(Shen *et al.* 2022)	China	(Shen et al. 2022)	China	quantitative	TAM	• perceived usefulness • hedonic motivation • price value	• efficiency • effectiveness
(Noble, Saville and Foster 2022)	Southeastern united states	(Noble et al. 2022)	Southeastern united states	quantitative	UTAUT	• technology acceptancy • Performance expectancy • Effort expectancy • Social influence • Behavioural intention	• Motivate • Enjoyment • presence
(Pan *et al.* 2021)	Ireland	(Pan et al. 2021)	Ireland	Mixed methods			• Knowledge gain • motivation
(Jang *et al.* 2021a)	South Korea	(Jang et al. 2021)	South Korea		eTAM	• teacher knowledge for technology integration, self-efficacy, motivational support • ease of use	attitudes
(Back *et al.* 2020)	Netherlands	(de Back et al.2020)	Netherlands			• Technology advancement • Availability of equipment	• Learning gains • interaction and collaborative learning
(Back *et al.* 2020)	America	(Shao et al. 2020)	America			• Usefulness • Engagement	immersion

3.1 Publications per year

It can be noted that from 2020 and 2021, there is a marked jump in the number of publications, from 2 in 2020 to 6 in 2022, and a slight fall to 5 in 2023

3.2 Publication per Continent

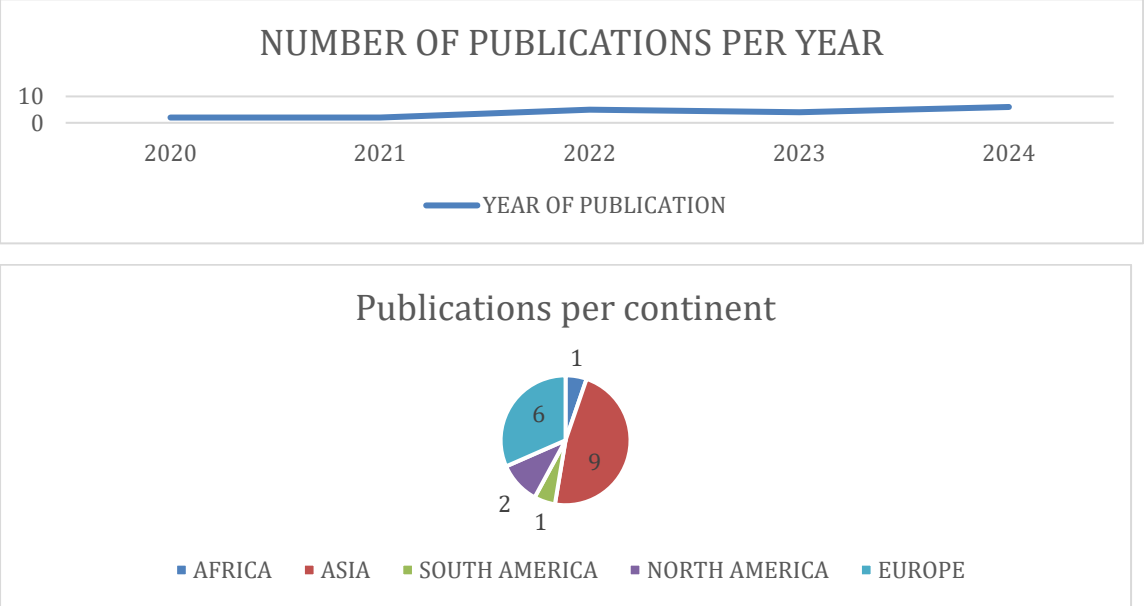

Figure 2. Publication per continent

Figure 2 shows publication by continent. One publication of our analysis are focused on Africa adopting VR and AR. Nine papers came from Asian countries. It can be noted that there are studies examining the use of AR and VR in African education. This underscores a significant gap in knowledge when compared to more developed regions like Asia, where 12 articles , Europe has 8 and North America has 4.

3.3 Classification by Theoretical Framework

Table 2. Theoretical framework summary

MODEL	COUNT	AUTHORS
TAM	5	Ibis M. Álvarez1etal, Shiwei Shen, Yuossef Asham, Joel Weijia Lai
UTAUT	4	Sean M. Noble etal, Dileep Kumar Murala, Diego Monteiro etal, Mohammad AL-Qudata,
OTHERS	14	Lin Haoming etal, Joel Weijia Lai,Vu Thi Thu Hoai etal, Qijia Shao, Ralf Doerner etal, Xingyu Pan, Trinh Le Tan, Insan Ganang Putranda, Sunder Kala Negia, Anna Flavia Di Natale, Brandon Antonio C´ardenas-Sainz, Rubina Dutta,Emmanuel Fokides, Sifang Zhang, Tycho T. de Back etal, Jaehong Jang, Fatima Zulfiqar, Aso Hajirasouli

From the studies, n=5 studies employed the TAM model, n=4 used UTAUT and n=14 the theoretical framework was not specified. The lack of theoretical underpinnings of existing literature poses a gap in literature There is need to ground research on theories as they can reveal other factors.

3.4 Our investigation identifies several key factors that influence the adoption of VR in education

Cost: The financial investment required to implement VR technology, including hardware, software, content development, and maintenance costs. VR has a lot of potential for teaching, but there are a few issues with equipment availability.(Doerner and Horst 2022)(Cárdenas-Sainz *et al.* 2023)(Sauer *et al.* 2022) have pointed out that high costs and durability difficulties are major obstacles. Furthermore, the large range of headsets on the market creates purchasing challenges and makes it difficult and time-consuming for students to have hands-on experience with various pieces of hardware. Furthermore, one major barrier is the high cost of purchasing VR headsets in large enough quantities for use in classrooms. Only one student may use a device at a time due to the necessary student-to-headset ratio, which could cause long wait times and interfere with the learning process. Besides the cost and availability of the equipment, virtual reality headsets can also be physically taxing for users due to their weight, which can lead to headaches and soreness, particularly in the neck and shoulders, for people learning the technology.

Perceived Usefulness: The extent to which VR technology is perceived as beneficial for enhancing learning experiences and achieving educational objectives. The usefulness of technology research consistently demonstrates the positive impact of VR and AR on student learning. Beyond enhancing comprehension of subject matter, previous studies indicate that VR/AR courses foster a broader skill set, including creativity, problem-solving, and presentation abilities. By creating immersive and engaging learning environments that simulate real-world scenarios, VR/AR can significantly improve student engagement(Al-Oudat and Altamimi 2022)(Zhang, Zhou and Zhao 2023) (Tan 2024)(da Silva *et al.* 2019). For instance, VR surgical simulations allow students to practice in controlled settings. Moreover, these technologies transcend geographical limitations, enabling students to collaborate with peers and experts globally, access diverse educational resources, and embark on virtual field trips. The simplicity and user-friendliness of VR interfaces and applications significantly influence user engagement. Intuitive VR technology can enhance learner motivation and participation in educational settings. Research indicates that immersive VR visualizations can improve students' comprehension and engagement (Tan 2024) (Al-Oudat and Altamimi 2022)

The elements that propel and maintain a user's interest and involvement in a virtual world are referred to as motivation in virtual reality. Immersion, agency, challenge, feedback, social connection, novelty, and personal relevance are some of these factors. The immersive qualities of virtual reality (VR), which combine real-time interaction, 3D registration, and the merging of virtual and physical settings with digital material, can greatly boost participant involvement in workout activities. (Dutta Mantri and Singh 2022)(Fokides and Antonopoulos 2024); (Haoming and Wei 2024a). Users feel like they are physically present, which leads to deeper involvement.

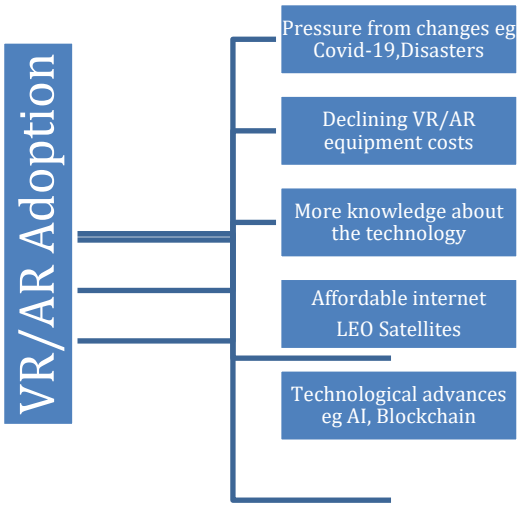

Figure 3 Drivers for the adoption of AR and VR.

Figure 3 shows the factors influencing the adoption of AR and VR in education. Devices for AR and VR are becoming more affordable due to technological advancements, which gives teachers easy access to VR and AR learning activities. Some of the drives are remote learning, international recognition for the institution, motivation, reduced cognitive load, and unlimited access to the required environment.

3.5 Benefits

Immersion and Engagement (Ndlovu Maphosa and Dube 2023) (Garcia-ruiz and Kapralos 2021) (Cárdenas-Sainz *et al.* 2023) argue that virtual reality aims at immersing users in real or virtual environments and experiences that perceptually surround them and are generated through computational units to simulate their physical presence within them. This means that an artificial environment would be created that enables students to fully participate and engage in their activities.

Simulating real-world scenarios Virtual reality can be used by students by simulating a real environment where they can fully practice what is in an artificial environment. For example, medical doctors can conduct an artificial operation in a controlled environment. Medical students that participated in VR surgical simulations gained confidence and skills. VR also lets students practice in a controlled setting, decreasing the hazards of hands-on training. (Negi 2024)(Murtinger *et al.* 2024) By keeping the scenarios consistent, police officers can stabilize their skills. By adjusting during this repetition, the flexible adaptation of the learned skills to changing circumstances can additionally be trained.

Personalized and adaptive learning By interacting through virtual reality, real time feedback is given to the audience (Pan *et al.* 2021)The author emphasizes AR's ability to give learners real-time feedback and let them learn at their own speed. VR and AR enable adaptive learning settings for a variety of learners, including students with special needs. Overcoming Geographical Barriers virtual reality comes with the benefit of being able to explore different area by giving your students an world overview for example students can virtually travel to a erupting volcano they can see and experience it. In online and remote learning, VR and AR can bridge the gap between students and teachers(Negi 2024).

4. Discussion

This systematic literature review examines the factors influencing the adoption of VR in education. Furthermore, it explores the opportunities and barriers for the adoption of the two technologies in the education framework. This research aims to identify factors influencing VR and AR adoption.(Haoming and Wei 2024b) highlight teacher training deficiencies, limited educational experience, weak conceptual foundations, inadequate research, and insufficient institutional support as barriers. . This is due to the rise in the adoption of AR and VR in education, as people are now aware of the technology. This could also be traced to the COVID-19 effect, where the world was affected and technological applications like robots, the internet, and VR/AR provided breakthroughs in many sectors, like the education sector(Tan *et al.* 2024). Several factors are likely to contribute to this gap. Developed countries may have initiated exploration of these technologies earlier, while Africa remains in the nascent stages of adoption. Moreover, studies from Asia frequently benefited from government funding, indicating a deliberate push to integrate AR and VR into educational frameworks. The impact of COVID-19 may also be influential (Monteiro et al. 2022) (Hoai et al. 2024)(Murala 2024)

Conversely, (Negi 2024) reports that participants found VR and AR to provide immersive and engaging learning experiences, fostering a deeper understanding of green energy and sustainability, thereby promoting technology adoption. (Al-Oudat and Altamimi 2022)corroborate Negi's findings, indicating that perceived behavioral control positively influences intentions to use the technology. (Doerner and Horst 2022)cite user experience and content scarcity as primary obstacles to widespread AR adoption, while(Cárdenas-Sainz *et al.* 2023) (Binti Fauzi *et al.* 2021)(Ndlovu, Maphosa and Dube, 2023)concur on the positive user acceptance and feedback across education, medicine, and training domains.

4.1 Opportunities derived from the adoption and application of VR and AR in Education

Back *et al.* (2020) claim that there are opportunities in VR/AR that provide a tangible demonstration of how virtual reality can be effectively designed and applied in CAVE environments. It showcases significant learning improvements, thereby paving the way for wider adoption of immersive technologies in education. Furthermore, the study highlights how immersive learning can introduce innovative support to enhance performance, particularly for individuals requiring targeted assistance. VR can also be used in training environments for security services. For example, police can be trained in dangerous environments where they can confront complex and

potentially dangerous situations that have a high potential for conflict (Murtinger *et al.* 2024)By manually adjusting different stress factors, such as the presence of weapons, shouting, or scenarios involving injured individuals, VR provides trainers with precise control over training conditions. This flexibility enables personalized training opportunities tailored to each participant.

Also, VR can be used by pre-service students at normal universities, which play a crucial role in advancing educational practices by integrating technology with teaching and learning (Zhang, Zhou and Zhao 2023)where students can carry out dangerous experiments where they are not possible physically .VR can serve as virtual classrooms, as exemplified during events like the emergence of COVID-19, where isolation measures necessitated continuous education without interruption (Ndlovu, Maphosa and Dube 2023)

Table 3. Classification of barriers

Main Barriers	**Sub-Barriers**	**Authors**
Technological Based	- High establishment and development costs. - limited learning materials. - Lack of infrastructure. - system instability, - computational of limitation, - inadequate functionality - Complex interface design. - system instability.	(Hsu & Liu 2021), (Zhang 2021), (Kim et al. 2023), Casa˜n-Pitarch and Gong (2021) (Amara et al. 2022); (Lee et al. 2019)
Teacher Based	- lack of training. - lack of educational experience. - lack of conceptual foundation. - lack of educational research. - lack of institutional support.	Wen 2021. Chen and Yuan (2023, pp. 1–29). (Lai and Cheong 2022).
Learners-Based	- user perceptions - negative effects on physical health, discomfort and sickness. - attention distraction. - insufficient instruction. - short learning period. - learning anxiety. - cognitive overload.	(Tsai 2020) (Hsu 2017) (Wen 2021).

We classified the barriers into 3 classes, namely, technological-based, teacher-based, and learner-based. Technological-based barriers are due to technological complications. Teacher based barriers are limiting factors on the part of the educator, and learner-based barriers hinder learners from effective use of technology.

5. Implications

5.1Methodological Implications

Seven studies employed quantitative methods, which excel in statistical analysis but may lack depth in providing nuanced insights (Fokides and Antonopoulos 2024)(Negi 2024)(Ndlovu *et al.* 2022)Previous research indicates that human behavior is influenced by intentions, suggesting that a positive attitude toward and perceived control over a system are key factors influencing the intention to use it(Al-Oudat and Altamimi, 2022)(Araújo *et al.* 2021)(Jang *et al.* 2021b)These studies utilized the Technology Acceptance Model, a framework in information systems that explores how users adopt and use virtual reality and augmented reality technologies, emphasizing that behavioral intention drives technology adoption. Factors such as perceived usefulness and perceived ease of use were considered in their analysis.

Three researchers included in our analysis have utilized UTAUT (Noble, Saville and Foster 2022)(Di Natale *et al.* 2024)The UTAUT framework identifies four key constructs that influence both the intention to use and the actual adoption of a technology: performance expectancy, effort expectancy, social influence, and facilitating conditions. These constructs suggest that variables such as age, gender, experience, and the voluntary nature of technology use can moderate the effects on behavioral intention and actual usage of the technology.

5.2Practical Contributions

A review of the literature reveals a concentration of research on AR/VR in education within developed regions, particularly in Europe. For example, in China, as compared to Zimbabwe, it fosters a culture of innovation, brings new solutions, and increases This underscores a significant gap in knowledge regarding the potential applications of these technologies in Africa. Despite limited resources for AR/VR implementation in Africa, focusing on a specific country like Zimbabwe could provide valuable insights. Examining how educators and students in Zimbabwe adopt these technologies, despite resource constraints, could contribute to a more comprehensive understanding of AR and VR's potential in developing regions (Figure 4).

5.3Proposed Conceptual Framework

The main contributions of this research are three-fold:

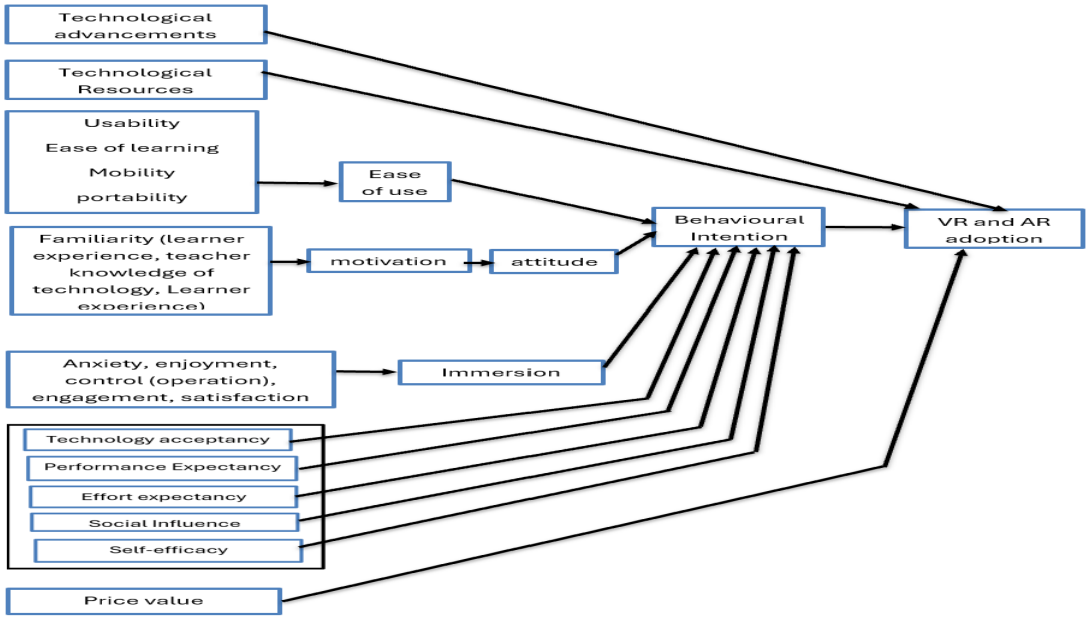

Figure 4. The proposed conceptual framework

This proposed framework provides us with an opportunity to explore other factors besides TAM and UTAUT. TAM bases its decision on the perceived intention to use technology as the key driver for technology adoption, (Negi 2024). In the study, other authors like (Tan et al.2024) and Hoai et al.2024) did not align with the well-known models; instead, they proposed factors like learner experience, multiple goals, career, and academic qualifications. Based on the findings, we propose a framework that combines well-known models like TAM with custom factors that do not align with the well-known ones. This adaptability ensures the proposed framework remains relevant to future research and comprehensive for decision-making.

6. Conclusion

6.1Conclusions, limitations and recommendations

In conclusion, this paper highlights the multifaceted nature of VR and AR adoption in education. Most of the articles reviewed focused on feedback from learners, teachers, and workers, proving the motivational power of the technologies. The barriers are equipment prices, technical complications, and accessibility. However, most studies envision a rapid adoption increase driven by affordability, accessibility, and enhanced content development. These findings demonstrate the importance of VR and AR in sustainability education and the necessity for innovation and collaboration in this dynamic field. From our research, it was noted that Africa is lagging in the adoption of AR and VR in education. Future research should be targeted at Africa. The language restriction is a limitation to our study since relevant papers written in non-English languages might have been omitted. The keywords that we used in the databases might have excluded some relevant articles. There might be a need to broaden the search strategy.

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