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Exploring pre-service teachers' intention to use virtual reality: A mixed method approach

Owolabi Paul Adelana [a,*], Musa Adekunle Ayanwale [b], Adebayo Monsur Ishola [c], Adekunle Ibrahim Oladejo [d], Habeeb Omoponle Adewuyi [e]

[a] Faculty of Wellbeing, Education and Language Studies, The Open University, UK
[b] Department of Educational Foundations, Faculty of Education, National University of Lesotho, Lesotho
[c] Department of Educational Technology, College of Specialized and Professional Education (COSPED), Tai Solarin University of Education, Ogun State, Nigeria
[d] Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Ojo, Lagos State, Nigeria
[e] Department of Educational Psychology, University of Johannesburg, South Africa

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ABSTRACT

Despite the increasing integration of virtual reality (VR) into classrooms globally, there is a dearth of empirical evidence concerning perceptions and behavioural intentions of pre-service teachers to employ the technology in Nigerian classrooms, particularly within the Technology Acceptance Model (TAM) framework. Consequently, this study examines pre-service perceptions and behavioural intentions to use VR. To accomplish this objective, we engaged pre-service teachers who voluntarily participated in this study by filling out an online survey for data collection. Quantitative and qualitative data were collected and analyzed using variance-based structural equation modelling, SmartPLS, and Atlas.ti, respectively. This data triangulation provided a comprehensive understanding of pre-service teachers' perceptions and behavioural intentions to use VR. Our findings, among others, reveal that perceived usefulness strongly predicts pre-service teachers' readiness and behavioural intention to use VR. This finding contributes to the ongoing discourse on how teachers, particularly trainee teachers, make decisions to integrate emerging technologies like VR in their classrooms, thereby offering valuable insights for policy formulation to enhance teacher training programs, especially regarding technology integration in Nigerian classrooms. It also emphasizes the importance of equipping teachers to address challenges related to adopting innovative technologies.

1. Introduction

In the 21st-century classroom, virtual, augmented, extended, and mixed realities are potentially promising and emerging technologies for enhancing conventional teaching approaches. Virtual reality (VR) is a computer-based simulation platform that enables users to experience a three-dimensional (3D) environment in a realistic style using suitable technology (Linowes, 2015). It uses 3D computer simulation to understand the user's position and activities in an interactive environment while delivering synthetic feedback to the user's senses, thereby making them experience the feeling of being immersed (Craig et al., 2009). VR has applications in several disciplines, including the arts and humanities (Hutson & Olsen, 2021), marketing (Anderson & Laverie, 2022), science, technology, engineering, and mathematics (STEM) (Barbara et al., 2022; Hernández-Chávez et al., 2021; Hutson & Olsen, 2021), among others. The application of VR in education has contributed significantly to the field due to its unique way of enhancing students' motivation and fostering hands-on learning (Brewer et al., 2015). In education, application and research into its benefits are fast becoming popular. In addition, VR is being used to explore novel approaches to delivering instructional content in conjunction with conventional teaching approaches (Marougkas et al., 2023). According to Zhang (2017), VR is effective for training learners in areas where access to real-world scenarios is expensive, difficult or impossible to reach. For instance, it might be challenging to schedule learners to go underwater to see how submarines work (Raja & Lakshmi, 2022), just as it will be expensive and time-consuming to schedule routine visits of biology students to surgical rooms to view live human internal organs and how they

* Corresponding author.
E-mail addresses: paulyetty@gmail.com, owolabi.adelana@open.ac.uk (O.P. Adelana), ma.ayanwale@nul.ls (M.A. Ayanwale), isholaam@tasued.edu.ng (A.M. Ishola), gbadegeshin86@gmail.com (A.I. Oladejo), adewuyihabeeb@gmail.com (H.O. Adewuyi).

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function. In this way, VR is considered efficient due to its ability to assist teachers in transferring skills from the virtual world to the real world (Krokos et al., 2019).

Certain features of VR can provide experiential elements in the learning process, and such features include its capacity to create interactive learning environments, hands-on learning, visual learning, Head Mounted Display (HMD) devices, and the ease and flexibility of using VR make learning using the technology a memorable one (Al Amri et al., 2020). VR, therefore, becomes relevant in learning environments that can potentially cause injuries or harm to learners and also helps reduce training costs. Given these, VR in education is a tool for providing real-world education prototypes (Mandal, 2013).

Despite many beneficial applications of VR in education, our observations have shown that it presently does not enjoy application in public higher education in Nigeria. Many factors may be responsible for these, chief of which is hypothesized to be the lack of technological infrastructure, teachers' attitudes, and perceptions of educational technologies. Integrating technology on a large scale in education has always been challenging for stakeholders, especially teachers and school administrators. This is one of the reasons for embarking on this study. Studies have examined the perceptions of teachers towards using VR in education (Abd Majid & Mohd Shamsudin, 2019), intention to use VR in education (Raja & Lakshmi, 2022), VR perception in education (Çoban et al., 2022; Kerzic et al., 2021; Zafar et al., 2020; Baxter & Hainey, 2019; Uygur et al., 2018), benefits of VR in education, and awareness of VR for teaching purposes (Soetan et al., 2020). However, to the best of our knowledge, no study has explored pre-service teachers' behavioural intention (BI) to use VR in education in Nigeria using the Technology Acceptance Model (TAM) (Davis, 1989). BI is an individual's subjective probability of performing a particular behaviour (Ducey, 2013), and a probable way of determining this, according to Fishbein and Ajzen (1975), is to find out if an individual intends to perform a particular task because the intention to perform a task is assumed to be the immediate precursor to performing such a task (Bagozzi, 1983). This study conceptualizes BI as a measure of the likelihood of trainee teachers to use VR in education. Nursiah (2018) reported that the intention to perform a behaviour is a good predictor for determining the actual use (actual technology usage), and therefore, the BI to use technology is a behavioural tendency of individuals to continue to use the technology (Kartika, 2009; Taylor & Baker, 1994; Usman et al., 2020).

Education, when handled by competent teachers, is a vital tool for fostering literacy as it empowers the people, and enable them to contribute to the progress and development of their nations (Odufuwa et al., 2022). We decided to examine the BI to use VR in education among pre-service teachers because they are still in the process of forming their teaching portfolios and would turn out to be relevant stakeholders in education when they become in-service teachers. Also, the acceptance and use of emerging technologies in education are to date, a subject of diverse studies, especially around pre-service teachers' intentions to use technology (Wong et al., 2021a). As technology advances globally, its integration into education creates different forms of learning modes, particularly at higher education levels (Olurinola & Adelana, 2022). We, therefore, believe that the report of this research will highlight relevant insights into the factors against pre-service teachers' BI at accepting and using emerging technologies such as VR-based education technology in their pedagogical processes in Nigeria. This is especially important in an era in which smart technologies continue to penetrate every sphere of human living, creating a world in which it seems that humans can no longer do without technologies in their daily lives (Ishola et al., 2022). Hence, pre-service teachers needed to align with emerging technologies to prepare for their in-service profession (Akinyemi et al., 2022; Adelana & Ishola, 2020). It is therefore believed that our findings may be useful to stakeholders and policymakers in education for designing and implementing modern curricula for teacher education programmes, as well as providing VR-supporting teaching and learning environments in schools. Teacher educators and trainers also need to be conversant with pre-service teachers' behavioural intentions to use VR in education to be able to, among other benefits, design and promote modern teacher training curriculum that will adequately take care of the need to produce teachers who are not just capable of handling and using emerging technologies in the teaching-learning processes, but who are also able to dynamically weather 21st-century educational challenges through effective use of technologies (Awofala et al., 2019). This paper is organized into introduction, literature review, theoretical framework and hypotheses development, methods, results, discussion, conclusion, limitation and future work.

2. Literature review

2.1. Virtual reality (VR) classifications

Broadly, the VR concept usually includes various terms such as augmented reality (AR) (Barroso et al., 2019; Milgram & Kishino, 1994), immersive VR (Kolomaznika et al., 2017), simulations, desktop-based VR, and virtual worlds (Merchant et al., 2014), each with specific technical requirements (Roda-Segarra et al., 2022). These technologies, used in virtual learning environments (VLEs) (Mikropoulos & Natsis 2011), present learners with uniquely personalised learning experiences which, according to Hite et al. (2019), can facilitate motivation and interests. The desktop-based VR allows users to interact with the virtual environment through the use of keyboards, mice, game consoles, or touch screens (Lee & Wong, 2014). The system has been reported to be particularly powerful in promoting presence (Hite et al., 2019). Two LCD panels mounted on a device resembling glasses and fixed per the user's eye location are used in HMD-based (head-mounted display) VR monitors to track the user's head direction and, in some situations, position (Sousa et al., 2009). To construct the VRE with the HMD, users must put on either goggles or a combination of headgear. Display screens provide fictitious surroundings for the viewer inside (Shibata, 2002). Some concerns reported with the HMD include the fact that it can impair the users' perceptions (Greenwald et al., 2017), is uncomfortable for long-term users (Lee et al., 2004), and can also cause eye fatigue (or sore eyes), according to Shibata et al. (2011). The CAVE (cave automatic virtual environment), which is a projection-based VR system, isolates users from their immediate surroundings and centres their entire audio-visual awareness in the virtual environment (Sherman & Craig, 2002). In the CAVE, VRE that may be shared by multiple users at once is created via this projection or holographic display, which projects holograms onto surfaces.

2.2. Educational benefits of VR

Empirical findings have shown the relevance of VR-based education in the diverse field of learning (Kim & Im, 2022) such as in STEM education (Pellas et al., 2020), math education (Lai & Cheong, 2022), computer science education (Agbo et al., 2021), foreign language learning (Peixoto et al., 2021; Pinto et al., 2021), K-12 and higher education (Di Natale et al., 2020; Pellas et al., 2021), science education (Arici et al., 2019; Durukan et al., 2020). This is just as AI and Intelligent Tutoring Systems (ITS) are compulsorily finding integration in education as the Fourth Industrial Revolution (4IR) deepens (Adelana & Akinyemi, 2021). Kim and Im (2022) identified some benefits of VR in education. They reported that VR in education creates authentic learning environments that foster effective learning transfer (Barsom et al., 2016). They argued that the key aspects of VR are immersion, reality, and interaction, and these create a kind of presence for learners in the virtual environment (Wirth et al., 2007; Witmer & Singer, 1998). Also, VR-based education supports learners' acquisition of competencies and skills including critical thinking, creativity, communication, and collaboration skills expected of the citizens and workforce of the 4th Industrial Revolution. These skills are germane in ensuring a workforce [problem-solvers] who can provide solutions to the foreseen challenges of the emerging future. In addition, VR-based education provides learners with the opportunity to experience virtual problems during their use of the technology for learning (Kim & Im, 2022). It is possible to develop instructions for students of varying ages and levels which they can use for private study during the temporary absence of the teacher (Adelana et al., 2021).

VR-based education contributes to providing equal educational opportunities for all learners. Learners in areas where important monuments or museums could not be visited due to their remote location, as well as learners requiring special needs education are catered for by VR-based education technology. In this wise, the technology offers various experiences for learners of diverse categories (Ke & Im, 2013; Parsons et al., 2017). With regards to the provision of multisensory experiences to learners, VR-based education makes available visual, auditory, and haptic feedback (Dehn et al., 2018; Pulijala et al., 2018) to learners. These stimuli-creating multisensory experiences assist learners in immersing themselves into the virtual learning world, thereby better. VR in education is most efficient when educational activities leverage the instructional capacities of the technology which could not have been satisfactorily met with other available approaches. Most empirical reports on VR to date (Costa & Melotti, 2012) contain some measures of engagement and motivation and consistently report that its use leads to increased interest and engagement with the subject matter. In support of this, Parong and Mayer (2018) reported that students were "happier, more excited, and less bored" when they were taught using VR technology, just as other reports also support this position (e.g., Cho, 2018; Kaplan-Rakowski & Wojdynski, 2018; Tai, Chen, & Todd, 2020; Velev, 2017).

VR-based education technology can foster memory recall (Pollard et al., 2020), and also fosters empathy (Constine, 2015). In the era in which modern instructional methods are essential to facilitate students' problem-solving skills (Ogunsola et al., 2021), VR-based educational technology, according to Hu-Au and Lee (2017) provides learners with a platform for creativity, and the ability to visualize difficult models, thereby making difficult concepts easier to grasp. Additionally, by utilizing technology in educational settings, students can illustrate their mental models, concretize abstract ideas, and improve cognitive learning (Dalgarno & Lee, 2010; Winn et al., 1997). Importantly, the use of VR-based technology in education promises the provision of a learning environment that is capable of generally improving learning, as well as intruding novel approaches to learners who require the most support (Hu-Au & Lee, 2017).

3. Theoretical framework and hypotheses development

To measure the acceptance of technology in education, theoretical models such as the Technology Acceptance Model (TAM), Innovation Diffusion Theory (IDT), Theory of Planned Behavior (TPB), Unified Theory of Acceptance and Use of Technology (UTAUT), and Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) (Ajzen, 1985, pp. 11–39; Ajzen & Fishbein, 1980; Venkatesh & Davis, 2000; Venkatesh et al., 2003), have been developed and improved on over the years to be able to empirically explore and explain the factors responsible for an individual's acceptance, rejection or continuous use of emerging technologies in education. As a result of the popularity of these theoretical models, various researchers have undertaken systematic literature reviews on them and suggested comprehensive analysis and evaluation of their applications, effectiveness and limitations (e.g., Venkatesh et al., 2016; Venkatesh & Davis, 2000). In this paper, the Technology Acceptance Model (TAM) underpins our study. The TAM enjoys several empirical supports for its ability to explain an individual's performance of a specified task based on his or her behavioural intention to perform the task. The TAM model has been extended by diverse studies and researchers (Abdullah & Ward, 2016; Martin, 2012) based on many factors and reasons, some of which include their conceptualizations of the TAM, contexts, needs, and research focus (Mailizar et al., 2021). As reported by Abdullah and Ward (2016), experience, self-efficacy, subjective norm, computer/technology anxiety, and perceived enjoyment, are some of the commonly used external factors for TAM.

In this study, we examined the factors predicting pre-service teachers' acceptance and use of VR in education. This was done based on an extended technology acceptance model (TAM). We explored perceived usefulness (PU), technology anxiety (TA), technology for social good (TSG), attitude towards technology (ATT), technology readiness (TR), technology perception (TP), and how they influence pre-service teachers' behavioural intention to use VR. We also explored the indirect effects of some constructs. The mediating role of technology perception (TP) on the relationship between attitudes towards technology (ATT) and the intention of pre-service teachers (BI) to use VR, and the relationship between technology readiness (TR) and pre-service teachers' behavioural intention to use VR. Also, we examined the mediating role of perceived usefulness (PU) on the relationship between technology readiness (TR) and pre-service teachers' behavioural intention to use VR. Finally, we explored the mediating role of attitude towards technology (ATT) on the relationship between technology readiness (TR) and the intention of trainee teachers (BI) to use VR. As a result of advancement in the use of emerging technologies (AI, AR VR, and robotics) in education globally, the need arises to prepare not just in-service teachers but also pre-service teachers in Nigeria to use these emerging technologies. Because VR technology is yet to be used in public education in Nigeria, we are unable to examine pre-service teachers' actual use of VR, therefore, we only examined their behavioural intention to use the technology. Our model and proposed hypotheses are shown in Fig. 1 below.

3.1. *Perceived usefulness (PU)*

Perceived usefulness defines the extent to which individuals believe that using a particular technology will improve their performance and productivity (Davis et al., 1989). PU measures how far an individual believes that the use of a particular technology will improve their performance. According to Venkatesh et al. (2003), it is vital to understand an individual's perceived benefits of and belief in technology. Previous studies have reported that PU is a construct that positively and significantly influences technology adoption and usage (Ayanwale, et al., 2022; Davis, 1989; Masrom, 2007; Sun et al., 2008; Venkatesh & Morris, 2000). According to Parasuraman (2000), people's readiness to use technology, otherwise known as the Technology Readiness Index, refers to the use of technology or technological products or services based on mental enablers and inhibitors related to optimism, innovativeness, discomfort and insecurity. All of these represent an individual's inclination to interact with technologies (Daniel et al., 2017). According to Wong et al (2021a), pre-service teachers will be ready and also use technology if they perceive the technology to be meaningfully beneficial for their work. Because of this, we proposed that:

H1. Perceived usefulness predicts pre-service teachers' readiness to use VR.

H2. Perceived usefulness predicts pre-service teachers' behavioural intention to use VR.

3.2. *Technology anxiety (TA)*

According to Spielberger (2010), anxiety is an emotional state that manifests via nervousness, feelings of tension, worry, and apprehension. It is often accompanied by physiological arousal. Technological anxiety therefore, according to Sääksjärvi and Samiee (2011), is the tendency of an individual to be apprehensive, or fearful about using innovative technologies or technological products, such as VR. TA is also the feeling of discomfort when using technology (Awofala et al., 2019). It is the fear

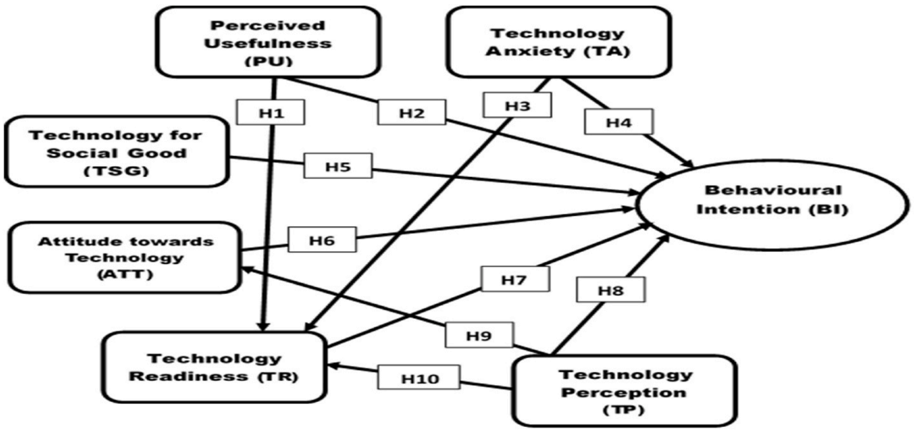

Fig. 1. Research model.

and apprehension displayed by individuals when considering the use of, or when using new technologies. Specifically, TA focuses on the individual's state of mind concerning the ability and willingness to use new technologies (Meuter et al., 2003). This has been linked to a lack of user experience which also tends to increase uncertainty (Hoeffler, 2003; Keszey, 2020). TA has been reported to play a positive and significant role in the educational use of technologies (Awofala et al., 2019). This is because an anxious individual will likely have some negative thoughts about using new technologies such as VR and is likely to avoid working with the technology. TA has been conceptualized as a multidimensional construct - psychological, operational, and sociological (Simsek, 2011). Empirical reports have shown that TA has a strong negative influence on computer-related activities including attitude towards technology and technological skills, perceived usefulness, and intention to use technology (Fatemi et al., 2017; Aktağ 2015; Rahimi & Yadollahi, 2011; Teo, 2008; Venkatesh et al., 2000). The findings revealed that TA increases an individual's struggle with and connection with technologies (Arigbabu, 2009; Awofala et al., 2019). Based on these reports, we hypothesized that:

H3. Technology anxiety predicts pre-service teachers' readiness to use VR.

H4. Technology anxiety predicts pre-service teachers' behavioural intention to use VR.

3.3. Technology for social good (TSG)

Fisher et al. (2018) posit that technology for social good first set out in computer science as a result of its impact on users of computers. In the use of emerging technologies such as AI, AV, and VR, the impact of social good has been seen in the use of technologies such as AI, robots, and chatbots which were designed to assist the ageing population (Chai, et al., 2020; Følstad et al., 2018). Conceptions about VR for social good in education, especially with the technology's capacity to provide a real-world prototype of a learning environment in areas that can potentially cause injuries or harm to learners, and also reduce costs of training, make the use of VR in education vital due to these capabilities (Alhalabi, 2019; Mandal, 2013). While more studies are needed on VR for social good and factors that influence its adoption among teachers (Alfalah, 2018), previous studies have reported factors such as behavioural beliefs, normative beliefs and control beliefs as likely to have either positive or negative influence on intention to either adopt or use VR in education (Mazman, 2019; Kennedy-Clark, 2011). According to Fishbein and Ajzen (2011), chances are high that people will use technology if the use of technology promotes social good. Concerning this, we proposed that:

H5. Technology for social good predicts pre-service teachers' behavioural intention to use VR.

3.4. Attitude towards technology (ATT)

Attitude, a key construct in the theory of reasoned action (TRA), is one of the factors that has been reported as influencing the intention to use technology (Suki & Ramayah, 2010). Attitude is a construct that is predicted to affect an individual's preparedness, acceptance and behaviour towards technologies (Selwyn, 1997). According to Ajzen (2020), individuals have diverse behavioural beliefs which invariably contribute to linking behaviour with the expected outcome. These beliefs, according to Zhang et al. (2013), have a direct influence on the process of technology adoption within individuals. Islam et al. (2013) confirmed and supported the existence of this positive relationship. Also, there is a growing body of studies suggesting that there is a strong link between attitude towards technology usage and behavioural intention (Davis, 1989; Šumak et al., 2011). Some of the studies include those of Dwivedi et al. (2021); Rana et al. (2017); Rana et al. (2016), Shanmugham and Ramya (2012), Yaghoubi et al. (2010), and Lee (2009), who reported that attitude influences behavioural intention (BU) to use technology. The authors argued that an individual's attitude is central to understanding his/her behavioural intention to use technology. As posited by Dwivedi et al. (2019), the main argument is that all things being equal, individuals form intentions to perform a particular behaviour towards which they have positive attitudes. Based on the literature, attitude is one factor that influences educators to accept and use emerging technologies (Huang & Liaw, 2005; Sang et al., 2010; Teo et al., 2009; van Braak et al., 2004). We, therefore, hypothesized that:

H6. Attitude towards technology predicts pre-service teachers' behavioural intention to use VR.

3.5. Technology readiness (TR)

Technology readiness, according to Garg (2017), is the sense of eagerness to use technological innovations. It is a person's inclination to adopt and use new or emerging technologies for achieving conceived goals. According to Parasuraman (2000), TR is a state of mind that results from a gestalt of mental enablers and inhibitors that collectively determine an individual's predisposition to use emerging technologies. TR is, therefore, a trait-like construct that captures an individual's general attitude towards accepting new technology. TR also demonstrates a person's overall openness to innovation. According to Yieh et al. (2012), the need arises to examine the impact of technology readiness on BI due to the critical role the construct plays in technology adoption. Therefore, to fully understand the complexity of relationships between an individual's technology adoption and utilization, the influence of technology readiness must be critically examined (Parasuraman, 2000). Given this, we proposed that:

H7. Technology readiness predicts pre-service teachers' behavioural intention to use VR.

3.6. Technology perception (TP)

To the best of our knowledge, there is a general dearth of studies examining teachers' perceptions of technology concerning VR in Nigeria. According to Boonmoh et al. (2021), recent works of literature present how teachers use common technological tools in their classrooms, as well as their perceptions of their use. Many of these technological tools are free to use and provide teachers with an easy approach to creating learning content. These technological tools, in themselves, will not be beneficial in education without teachers' perceptions, which might lead to using them or not in the classrooms. The decision to use technology or not mostly depends on teachers' perceptions of such technologies as this might influence their BI to use the technology during in-service years. While several studies have been carried out on pre-service teachers' technology perceptions (e.g. Or-Kan & Ahmad, 2018; Eyyam et al., 2011; Baltaci-goktalay & ozdilek, 2010), none has examined pre-service teachers' technology perceptions and its controlling effect on intentions to use VR in education. We, therefore, proposed that:

H8. Technology perception predicts pre-service teachers' behavioural intention to use VR.

H9. Technology perception predicts pre-service teachers' attitude towards VR.

H10. Technology perception predicts pre-service teachers' readiness to use VR.

We also tested the following indirect effect relationships:

H11. Technology perception mediates the relationship between attitudes towards technology and pre-service teachers' behavioural intention to use VR.

H12. Technology perception mediates the relationship between technology readiness and pre-service teachers' behavioural intention to use VR.

H13. Perceived usefulness mediates the relationship between technology readiness and pre-service teachers' behavioural intention to use VR.

H14. Attitude towards technology mediates the relationship between technology readiness and pre-service teachers' behavioural intention to use VR.

4. Methods

4.1. Participants

The study participants comprised 231 undergraduate pre-service teachers who major in Educational Technology at a public university of education in Nigeria. This sample is made up of trainee teachers in their second, third and fourth years of the teacher education programme, and have received not less than two years of several training in technology integration in education. The pre-service teachers comprised 124 (53.7%) 400-level undergraduates (year 4), 54 (23.4%) 300-level undergraduates (year 3), and 53 (22.9%) 200-level undergraduates (year 2), respectively. Concerning gender, there were 88 (38.1%) male and 143 (61.9%) female undergraduate pre-service teachers. All the participants voluntarily took part in the survey. The ages of the trainee teachers range from 18 to 30 years, with the majority of them being in-between 21 to 25 years. The summary of the demographic information of the trainee teachers is given in Table 1. All the trainee teachers sampled in the study have neither taught in authentic teaching and learning environments nor used VR-based educational technology before. However, as trainee teachers majoring specifically in the field of Educational Technology, they have been introduced to emerging technologies in education such as artificial intelligence (AI), robotics, augmented reality, and virtual reality, among others, as required by the scope of their courses as prospective educational technologists. They have also taken several courses on the diverse roles of technology in education and their respective integration approaches. This is in addition to several other courses on pedagogy and other educational courses intended at preparing trainee teachers to become well-trained teachers in the nearest future. Hence, they are knowledgeable about emerging technologies and their application in education.

Table 1
Participants' demographic profile.

Variable	Categories	Frequency	Percent
Gender	Male	88.0	38.1
	Female	143.0	61.9
Age group	Less than or equal 20 years	44.0	91.0
	21 – 25 years	160.0	63.9
	26 – 30 years	27.0	11.7
Level	200 level	53.0	22.9
	300 level	54.0	23.4
	400 level	124.0	53.7

4.2. Survey instrument

The survey instrument (adapted from Khukalenko et al., 2022; Ayanwale et al., 2022), was divided into three sections. The first section on demographics of the trainee teachers requested their gender, age and level of study, while the second section contained items on technology perceptions (TP) (reliability = 0.81) (5 items) which were adapted from the previous work of Khukalenko et al. (2022). The paper assessed teachers' perceptions of VR technology usage in classrooms. The items for other constructs in the second section - perceived usefulness (PU), technology anxiety (TA), technology for social good (TSG), technology readiness (TR), attitude towards technology (ATT), and behavioural intention (BI) were adapted from Ayanwale et al. (2022). The items were conscientiously adapted to suit the context of this study. Perceived usefulness (PU) ($r = 0.85$), technology anxiety (TA) ($r = 0.70$), technology for social good (TSG) ($r = 0.75$), and attitude towards technology (ATT) ($r = 0.89$) have 4 items each, while technology readiness (TR) ($r = 0.82$) and behavioural intention (BI) ($r = 0.86$) have 5 items each. In all, there were 31 items in the survey instrument finally used. The options provided in the instrument were based on the seven-point Likert scale with strongly agree (7-point) being the highest and neutral (1-point) being the lowest. The third section of the instrument is an open-ended section for the participants to write their conceptions of VR generally and VR in education, specifically. The section requested the participants to answer two open-ended (qualitative) questions asking about what they generally know about VR, and specifically about its application in education. Spaces were provided in the survey instrument for them to write out their views on the questions asked.

4.3. Data collection procedure

The adapted survey instrument was converted to a web-based instrument using Google Forms. The link generated after creating the web-based survey was shared for data collection via the undergraduate trainee teachers' online platforms to reach a wider audience. The link was shared with a representative of the Department of Educational Technology of the university. The need for the study and other relevant information was shared with the representative and necessary permissions and approval were also obtained before the trainee teachers participated in the study. Also, the trainee teachers were made to understand that the study seeks their voluntary participation by giving their consent before participating, the absence of which would not lead to any form of punishment for non-participation. They were also assured of confidentiality and protection of their data before the link to access the form was finally shared with them by their departmental representative. Hence, their consent was sought and obtained before filling out the survey. Only those who consented to take part in the study went ahead to respond to the items in the survey during the three weeks that it was left open for data collection. After the expiration of the three weeks, access to the link was removed.

4.4. Data analysis

To provide a comprehensive interpretation of the results, quantitative and qualitative analysis methods were employed in the study. Quantitative analysis was performed using variance-based structural equation modelling with SmartPLS software version 4.0.8.5 (Ringle et al., 2022). A confirmatory composite analysis (CCA) was first performed to validate the research instruments and factor structures. To ensure the validity of the measures, CCA used item loadings, Cronbach alpha (CA), composite reliability (CR), average variance extracted (AVE), and HeteroTrait-MonoTrait ratio (HTMT). Secondly, the study tested the research hypotheses and explored the relationships among latent variables such as technology perception (TP), perceived usefulness (PU), technology anxiety (TA), technology for social good (TSG), technology readiness (TR), attitude towards technology (ATT), and behavioural intention to use VR technology (BI) using a structural model evaluation. The study also estimated the mediating effects of TP on BI through ATT and TR, PU on BI through TR, and TA on BI through TR. We applied bootstrapping as a resampling method with 10000 repetitions (Hair et al., 2022) to increase the robustness of our results. Overall, several advanced statistical techniques were used to test the study's research hypotheses and analyze relationships between latent variables associated with behavioural intentions to use virtual reality. Importantly, the inclusion of qualitative data analysis in this study is based on the nature of the topic and the desire to gain detailed insights. By using this method, we aim to uncover participants' perceptions, feelings, and motivations regarding virtual reality in education. Considering how this field is constantly changing and evolving, qualitative analysis emerges as a suitable choice for this exploratory study, providing avenues to identify emergent themes and facilitating a deeper understanding of pre-service teachers' intention to embrace virtual reality. Also, Atlas.ti software version 9.1.7 (Atlas.ti, 2022) was used to analyze the qualitative data, which was triangulated with the quantitative data. Atlas.ti allows researchers to organize and code large amounts of audio, video, and graphical data using a computer program designed for qualitative data analysis.

5. Results

In Table 2 of the study, the fit of the reflective measurement model was evaluated using several fit indices, including unweighted least squares discrepancies (d_ULS), geodesic discrepancies (d_G), Standardized Root Mean Squared Residuals (SRMR), and Normed Fit Index (NFI). The fit indices were used to assess the goodness of fit between the latent constructs and measured variables. The NFI is a measure that calculates the discrepancy between the observed covariance matrix and the hypothesized model covariance matrix, with values closer to 1 indicating a better fit. An NFI value of 0.90 or higher is considered to indicate a good fit. In addition to the NFI, a model fit is also considered valid if the SRMR is less than 0.08 and if the d_ULS and d_G values from the saturated model are less than the bootstrapped values at 95% of the estimated model. The results showed that the SRMR was less than 0.08 and the d_ULS and d_G values from the saturated model were less than the bootstrapped values at 95% of the estimated model, which indicates a good fit. However, the NFI value was slightly below the benchmark of 0.90, although it was very close. Despite this, the other fit indices were satisfactory, suggesting that the model fit was acceptable. These findings support the requirement for model fit as suggested by Henseler et al. (2016), Molefi and Ayanwale (2023), and Quintana and Maxwell (1999).

Table 3 presents the item loadings, reliability, and convergent validity of the constructs used in the study. All items were loaded under their respective latent variables, and items with low factor loadings (such as items TP2, TP4, TP5, TP7, and TP8) were removed to enhance the quality of the proposed model. The loading values ranged from 0.643 to 0.902, which is following the recommended range for PLS-SEM models (Hair et al., 2016, 2022). The data were checked for collinearity issues using the Variance Inflation Factor (VIF), and the results revealed values ranging from 1.199 to 3.247, which is below the recommended cut-off point of 3.3 (Kock, 2015; Hair et al., 2016). Further, to establish the convergent validity of the study, Composite Reliability (CR) and Cronbach alpha (CA) values of the latent variables were computed. The

Table 2
Model fit indices.

	Saturated model (sat)			Estimated model (est)		
	Value	HI 95	Interpretation	Value	HI 95	Interpretation
SRMR <0.08	0.051	0.023	Supported	0.051	0.026	Supported
d_ULS sat < HI 95	0.204	0.424	Supported	0.204	0.573	Supported
d_G sat < HI 95	0.246	0.301	Supported	0.246	0.502	Supported
NFI >0.90	0.879					

Table 3
Construct reliability and validity.

Manifest variable	Item loading	CA	CR	AVE	VIF
ATT1	0.806	0.891	0.925	0.755	1.822
ATT2	0.899				3.286
ATT3	0.902				3.247
ATT4	0.865				2.355
BI1	0.863	0.860	0.899	0.640	2.368
BI2	0.797				1.971
BI3	0.76				1.804
BI4	0.779				1.995
BI5	0.798				1.882
PU1	0.825	0.850	0.899	0.690	1.868
PU2	0.781				1.803
PU3	0.883				2.576
PU4	0.832				1.916
TP1	0.701	0.817	0.871	0.575	1.605
TP10	0.768				1.840
TP3	0.790				1.786
TP6	0.717				1.428
TP9	0.809				2.044
TR1	0.739	0.827	0.878	0.592	1.638
TR2	0.779				1.891
TR3	0.805				1.990
TR4	0.836				2.030
TR5	0.678				1.589
TA1	0.651	0.703	0.812	0.521	1.199
TA2	0.671				1.391
TA3	0.725				1.514
TA4	0.827				1.386
TSG1	0.643	0.752	0.842	0.574	1.316
TSG2	0.752				1.657
TSG3	0.844				1.900
TSG4	0.777				1.498

Note: TP - technology perception, PU - perceived usefulness, TA - technology anxiety, TSG - technology for social good, TR-technology readiness, ATT - attitude towards technology, BI - behavioral intention to use VR technology, item loading >0.60, AVE >5.0, CR > 0.70, CA > 0.70, VIF <3.3.

CR and CA values ranged from 0.812 to 0.925 and 0.703 to 0.891, respectively, which meets the recommended threshold of 0.70 (Ayanwale et al., 2023; Chin, 1998; Hair et al., 2017, 2022; Henseler et al., 2009; Taber, 2018). Additionally, the Average Variance Extracted (AVE) was calculated and found to meet the recommended threshold of 0.50, with values ranging from 0.521 to 0.690 (Hair et al., 2016, 2022; Oluwadamilare & Ayanwale, 2021). These results confirm the reliability and convergent validity of the study's measurement model.

The reflective measurement model uses the HeteroTrait-MonoTrait (HTMT) correlation ratio to assess discriminant validity, as presented in Table 4. This ratio compares correlations between constructs (HeteroTrait) and correlations within constructs (MonoTrait). An HTMT ratio of less than 0.85 suggests that the correlation between different constructs is significantly weaker than the correlation within each construct, indicating good discriminant validity (Ayanwale et al., 2022; Henseler et al., 2015). In PLS-SEM, a rule of thumb is to compare the HTMT ratio to 0.85, and values above 0.85 indicate a potential problem with discriminant validity, requiring further investigation. The results in Table 4 indicate that the study model has good discriminant validity, with an HTMT ratio of less than 0.85 (Henseler et al., 2015). Additionally, the model shows good convergent and discriminant validity and reliability, indicating that the variables are appropriately measuring their corresponding constructs.

The study examined the direct relationship between the adopted exogenous variables and the criterion variable and tested the hypothesized relationship between the variables (Hair et al., 2016; Kock, 2016). (H1) Perceived Usefulness → Technology Readiness (β = 0.553, t = 7.064, C.I = 0.421-0.677, p-value = 0.000) (H2), Perceived Usefulness → Behavioral Intention to use VR Technology (β = 0.225, t = 2.123, C.I = 0.047-0.390, p-value = 0.017) (H3), Technology Anxiety → Technology Readiness (β = 0.193, t = 3.389, C.I = 0.101-0.285, p-value = 0.000) (H4), Technology Anxiety → Behavioral Intention to use VR Technology (β = 0.012, t = 0.269, C.I = -0.060-0.083, p-value = 0.394) (H5), Technology for Social Good → Behavioral Intention to use VR Technology (β = 0.006, t = 0.047, C.I = -0.207-0.215, p-value = 0.481) (H6), Attitude towards Technology→ Behavioral Intention to use VR Technology (β = 0.179, t = 1.957, C.I = 0.014-0.318, p-value = 0.0024) (H7), Technology Readiness → Behavioral Intention to use VR Technology (β = 0.508, t = 5.830, C.I = 0.362-0.648, p-value = 0.000) (H8), Technology Perception → Behavioral Intention to use VR Technology (β = -0.010, t = 0.156, C.I = -0.122-0.088, p-value = 0.438) (H9), Technology Perception → Attitude towards Technology (β = 0.543, t = 7.110, C.I = 0.396-0.653, p-value = 0.000), and (H10) Technology Perception → Technology Readiness (β = 0.141, t = 1.979, C.I = 0.026-0.260, p-value = 0.0024).

As shown in Table 5, out of the ten hypotheses tested, seven were significant (H1-H3, H6-H7, H9-H10) and three insignificant (H4-H5, H7-H8). Moreover, according to Table 5, an R-squared value in PLS-SEM analysis indicates the proportion of variance explained by the exogenous latent variables. Based on the model's R-squared value of 0.295, exogenous variables explain 29.5% of the variance in attitude toward technology, whereas, in the R-squared value of 0.703, the exogenous variables account for 70.3% of the variance in Behavioral Intention to use VR Technology. In addition, the R-squared value of 0.533 for Technology Readiness and the exogenous variables account for 53.3% of the variance. As a result of these R-squared values, the exogenous variables moderately to strongly correlate with the endogenous constructs. In the case of Behavioral Intention to Use VR Technology, the high R-squared value indicates that exogenous variables strongly influence pre-service teachers' intention to use VR technology. However, other factors not included in the model may contribute to pre-service teachers' attitudes toward technology, as shown by the relatively low R-squared value for attitude toward technology. Also, Fig. 2 depicts the graphical representation of the hypothesis and mediation model that was tested in the study. It displays the direct relationships among the variables, and the mediating role of Attitude towards Technology and Technology Readiness on the relationship between the independent variables (Technology Perception, Perceived Usefulness, and Technology Anxiety) and the dependent variable (Behavioral Intention to use VR Technology). The arrows represent the direction and strength of the relationships among the variables, while the numbers on the arrows indicate the standardized path coefficients.

Table 4
Discriminant validity- Heterotrait-monotrait ratio.

Construct	ATT	BI	PU	TP	TR	TA	TSG
ATT							
BI	0.812						
PU	0.832	0.82					
TP	0.622	0.52	0.64				
TR	0.563	0.64	0.817	0.575			
TA	0.331	0.418	0.419	0.249	0.504		
TSG	0.552	0.853	0.69	0.782	0.636	0.447	

Note: TP - technology perception, PU - perceived usefulness, TA - technology anxiety, TSG - technology for social good, TR-technology readiness, ATT - attitude towards technology, BI - behavioral intention to use VR technology, HTMT <0.85.

The study also explored the mediating effects of Attitudes towards Technology and Technology Readiness on the relationship between Technology Perception, Perceived Usefulness, Technology Anxiety, and Behavioral Intention to use VR Technology. Table 6 lists the path coefficients of the mediators. The results indicate that (H11) Technology Perception has a positive and significant effect on attitude toward technology, which further affects the BI to use VR Technology (β = 0.097, t = 1.865, p-value = 0.031). This suggests that pre-service teachers' positive perception of technology is likely to increase their intention to use VR.

Similarly (H12), Technology Perception has a significant positive effect on Technology Readiness, which in turn affects the Behavioral Intention to use VR Technology (β = 0.072, t = 1.927, p-value = 0.027). This implies that pre-service teachers who perceive VR technology as useful and easy to use are more likely to be ready to use it, which increases their intention to use it in the classroom. Moreover (H13), Perceived Usefulness has a significant positive effect on Technology Readiness, which in turn affects the Behavioral Intention to use VR Technology (β = 0.281, t = 4.233, p-value = 0.000). This suggests that pre-service teachers who perceive VR technology as useful and relevant for their teaching practice are more likely to be ready to use it, which increases their intention to use it in the classroom, whereas (H14) Technology Anxiety has a significant negative effect on Technology Readiness, which in turn affects Behavioral Intention to use VR Technology. This indicates that pre-service teachers who experience anxiety about technology may be less ready to use it, which decreases their intention to use it in the classroom.

Further, study participants' responses were analyzed qualitatively to determine their perceptions and acceptance of VR in their pedagogical routine. Based on the research questions developed to guide the study, themes, and sub-themes were developed. The focus of this theme is on how study participants perceive virtual reality. The section is grouped under a central theme, "The perception of VR". The central theme is then divided into three concepts that examine the perception of VR among the study participants. These include knowledge of VR, ways of assessing VR, and the benefits of VR. We have analyzed and discussed each concept critically below. Also shown in Fig. 3 are responses generated by the participants regarding their perceptions of VR.

5.1. Knowledge of VR

The result of the analysis (see Fig. 3a and b) conducted on the textual responses of the respondents show varying responses on their knowledge of what VR is. Multiple responses were generated from the question posed to the respondent to examine their understanding of what VR is. A

Table 5
Direct path coefficient for tested model.

Relationships	B	SD	t-value	5%	95%	p-values	Remarks
H1: PU - > TR	0.553	0.078	7.064	0.421	0.677	0.000	Supported
H2: PU - > BI	0.225	0.106	2.123	0.047	0.391	0.017	Supported
H3: TA - > TR	0.193	0.057	3.389	0.101	0.285	0.000	Supported
H4: TA - > BI	0.012	0.043	0.269	-0.060	0.083	0.394	Not supported
H5: TSG- > BI	0.006	0.129	0.047	-0.207	0.215	0.481	Not supported
H6: ATT - > BI	0.179	0.091	1.975	0.014	0.318	0.024	Supported
H7: TR - > BI	0.508	0.087	5.830	0.362	0.648	0.000	Supported
H8: TP - > BI	-0.010	0.063	0.156	-0.122	0.088	0.438	Not supported
H9: TP - > ATT	0.543	0.076	7.110	0.396	0.653	0.000	Supported
H10: TP - > TR	0.141	0.071	1.979	0.026	0.260	0.024	Supported
	R-square						
ATT	0.295						
BI	0.703						
TR	0.533						

Note: TP - technology perception, PU - perceived usefulness, TA - technology anxiety, TSG - technology for social good, TR-technology readiness, ATT - attitude towards technology, BI - behavioral intention to use VR technology, T = $t > 1.645$ (one-tail test), $p < 0.05$.

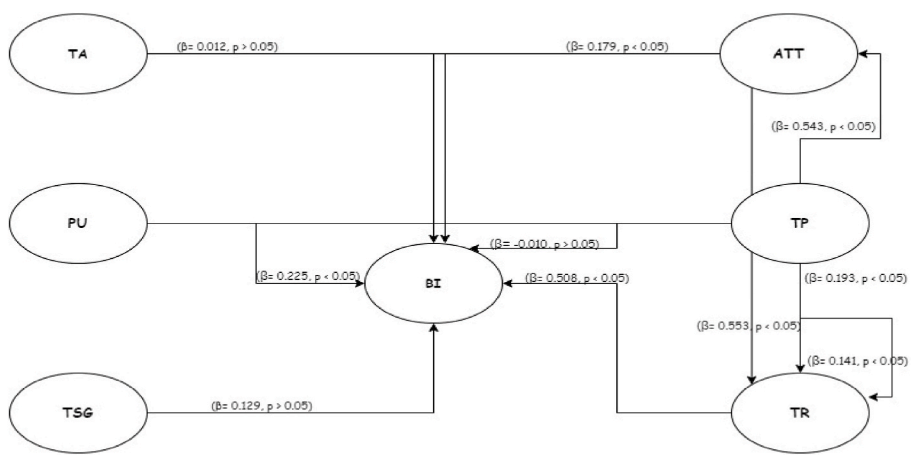

Fig. 2. Structural model.

Table 6
Indirect effect relationship.

	β	Std. Dev.	t-value	p-values	Remarks
H11: TP- > ATT - > BI	0.097	0.052	1.865	0.031	Supported
H12: TP - > TR - > BI	0.072	0.037	1.927	0.027	Supported
H13: PU - > TR - > BI	0.281	0.066	4.233	0.000	Supported
H14: TA - > TR - > BI	0.098	0.033	2.974	0.001	Supported

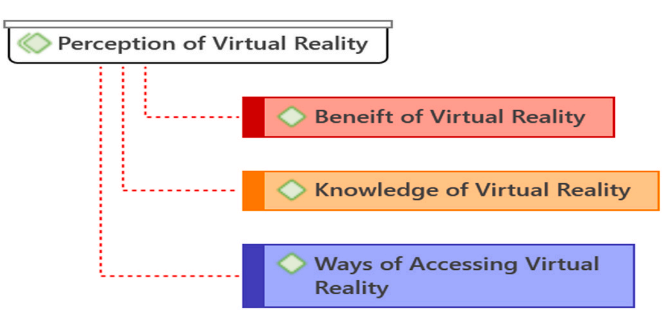

Fig. 3a. Network showing perception of VR.

critical analysis of the responses showed that the understanding of VR differs from one respondent to the other. One of the respondents said VR "*is a computer-generated environment with scenes and objects that appear to be real, making the user feel they are immersed in their surroundings*". Many of the respondents' responses agree with the respondent's definition of VR, however, other respondents have varying responses and definitions of VR. Another respondent asserted that "virtual reality can also be referred to as artificial intelligence …. it means creating robots or electronics that can also do what humans can do". In contrast to the latter response on the knowledge of VR, another respondent asserted that "*VR is a simulated experience that employs pose tracking and 3D near-eye displays to give the user an immersive feel of a virtual world*". Other respondents asserted that "VR means exploring outside the world".

Furthermore, other responses elicited from the participants show more varying positions as to the knowledge of VR. A respondent asserted that VR "*Is a representation of content or objects that can be seen and watched in a 2-dimensional form such as graphics, photography, maps, and many likes*". In line with the response of the previous respondent, another respondent asserted that VR "Is a 3d display", while another wrote that "*VR is an artificial environment which is experienced through sensory stimuli such as sounds and sights*". In addition, another respondent affirmed that VR is "*an experience that employs 3D near-eye displays to give the user an immersive feel of a virtual world*", while a participant also wrote that VR is "*the computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way*". In addition, a particiapnt wrote that VR is "*the use of computer modelling and simulation that enables a person to interact with an artificial three-dimensional (3-D) visual or other sensory environment*". Analysis of these responses show that although the respondents have varying perceptions and definitions of VR, the majority of their definitions are similar to each other.

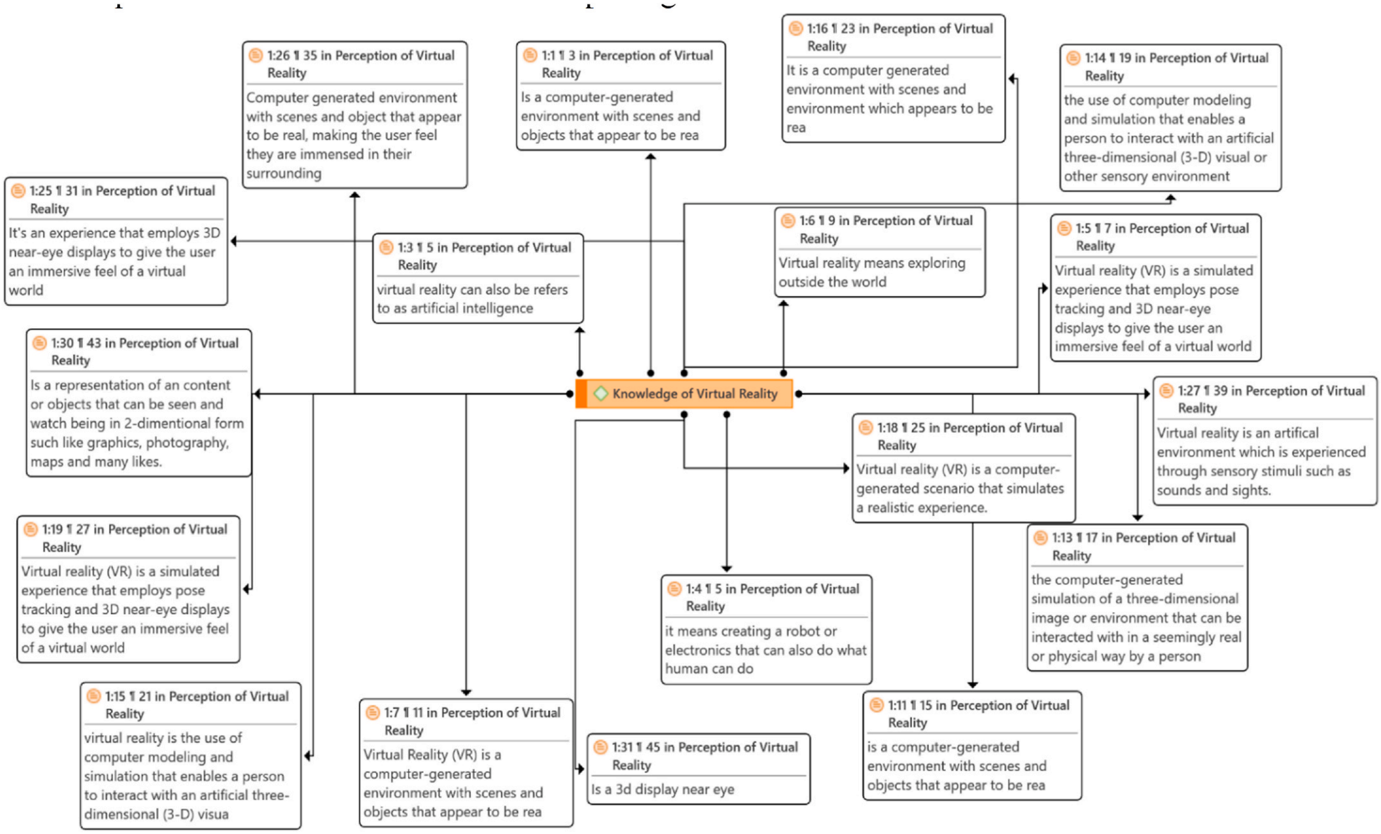

Fig. 3b. Network showing knowledge of VR.

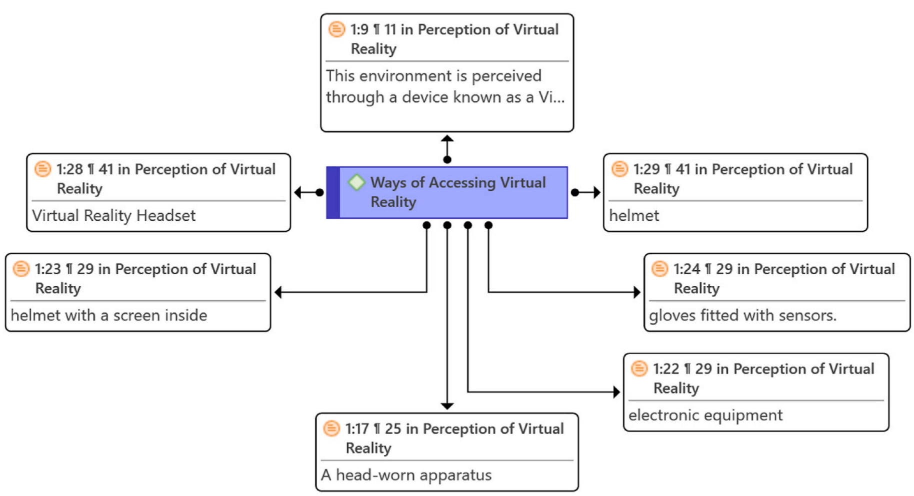

Fig. 3c. Network showing ways of accessing VR.

Summarily, from the responses of the participants, and from the critical analysis conducted on the responses that we collected to examine the perception of VR, we infer that a majority of the respondents have some level of understanding of VR. Their responses were different from each other in terms of the way it was stated, however, they are related and share similar semantic features. Therefore, it can be concluded that many of the participants have a good grasp of what VR is. We concluded that most of the participants' knowledge of VR is abstract/theoretical, not founded on their practical experience about VR.

5.2. *Ways of accessing VR*

To further ascertain the level of perception of the respondent's knowledge of VR, responses were generated to examine how VR can be assessed (see Fig. 3c). A participant asserted that VR can be assessed through the use of "*special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors*". Other respondents affirmed that VR can be assessed through the use of a "helmet", "a head-worn apparatus", or a "VR Headset or helmet".

Summarily, from the critical analysis performed on the responses , we concluded that VR can be assessed through the use of VR headsets, helmets, or other electronic gadgets and devices. Analysis of the varying

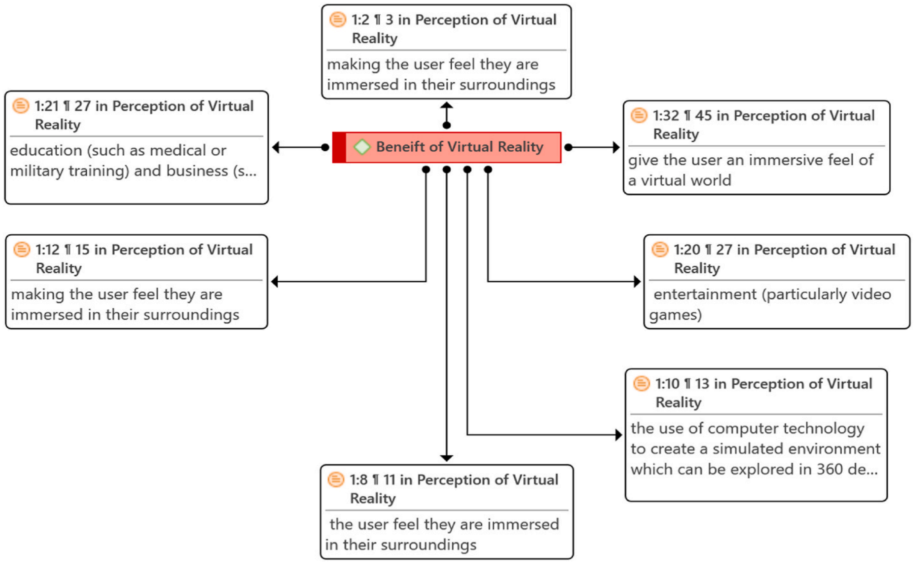

Fig. 3d. Network showing the benefit of VR.

responses generated led to the conclusion that the participants have a good grasp of VR. However, these responses are most likely to be based on an abstract but not a practical experience of VR. The responses generated concerning how VR could be accessed were few, most of which were speculative in nature and not really from a concrete idea of how VR can be assessed.

5.3. Benefits of VR

Furthermore, to ascertain the level of perception of VR, the responses generated show respondents highlighting the benefits of VR (see Fig. 3d). The respondents asserted that VR "gives the user an immersive feel of a virtual world". Other respondents affirmed this response by stating that VR can "create the feeling of immersive environment in users". Other respondents affirmed that one major benefit of VR is "the use of computer technology to create a simulated environment which

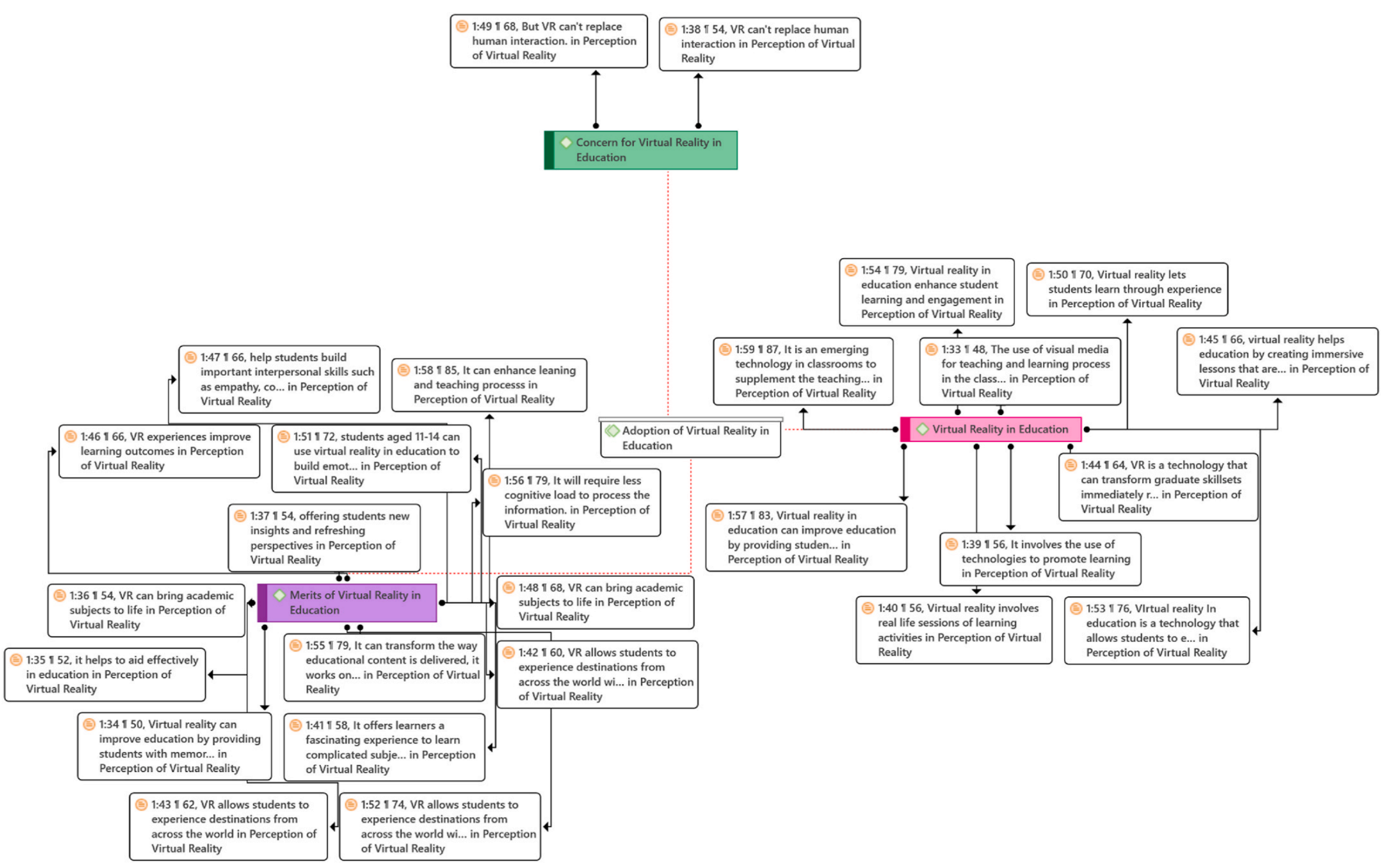

Fig. 4. Network showing adoption of VR in Education.

can be explored in 360°". In addition, another respondent stressed the benefit of VR by stating that VR can be used for "entertainment (particularly video games)". Another respondent stressed that it can be adopted for teaching and learning in "education (such as medical or military training)" and in "business (such as virtual meetings)". Summarily, the results show that the respondents understand the benefits of VR. The responses of the respondents were similar to each other, suggesting that their understanding of the benefits of VR is related to their perception of VR.

Further, the second theme examines respondents' perceptions of VR adoption in education. To explore this, three major concepts were developed using the responses that we collected. These are VR in Education, the merits of VR in Education, and concern about VR in Education. A critical analysis of the responses elicited from respondents regarding the three core concepts was conducted. Fig. 4 shows the relationship between the themes, and the concepts generated on them, along with direct quotations derived from the respondents' responses.

5.3.1. VR in education

The result of the analysis conducted on the textual information gotten from the respondents showed varying responses of their views concerning adopting VR in Education (see Fig. 4). Some of the respondents asserted that *"VR in education enhances students' learning and engagement"*. Other respondents stressed that "VR *is an emerging technology in the classroom to supplement the teaching of a subject or topic* ". Another respondent's view of the adoption of VR in education is optimistic based on the assertion that "*VR is a technology that can transforms graduate skillsets immediately recognized through practical applications*". Summarily, the responses elicited from the respondents show that they hold an optimistic view, and they see the possibility of incorporating VR into the instructional processes. Therefore, the responses show that they hold a positive view on the adoption of VR in education and that the use of VR will enhance teaching and learning as it will make learning more practical while also giving learners the feel of concepts being taught in real life through the use of VR devices.

5.3.2. Merits of VR

The result of the analysis done on the responses aimed at examining the perception of the study participants on the acceptance of VR in instructions show that the respondents understand the merits of VR for instructional purpose. While the responses show diversified views, yet they all show the advantages and benefits of adopting VR in instructions. One of the study respondents asserted that "VR can improve education by providing students with memorable and immersive experiences that would otherwise not be possible in the real classroom". Another respondent affirmed the statement by stating that "VR can bring academic subjects to life, offering students new insights and refreshing perspectives. But VR can't replace human interaction". In addition, other responses from the respondents follow the trend of the responses stated by the previous respondents but all highlights the crucial benefits of VR in education. In summary, the result shows that VR will be of great benefit to teaching and learning because it is able to assist learners have a better grasp of concepts that are being taught in the classroom.

5.3.3. Concerns for VR

The responses on pre-service teachers concern about using VR in education, though from very few respondents, yet all point to the direction that "*VR can't replace human interaction*". Some other respondents also affirm this position. This view is likely to be connected with the pre-service teachers' understanding of the inability of technologies, VR inclusive, to replicate the depth of emotional connections between teachers and their students in the classroom settings. These might not be unconnected to the belief that face-to-face interactions between teachers and students provide a level of emotional engagement that VR may not match because teacher-student interactions involve some intricate social cues and contexts that are complex and dynamic.

6. Discussions

This study presents novel findings documenting trainee teachers' BI, readiness, and attitude towards the use of VR-based technology in enhancing teaching-learning activities. The study explored perceived usefulness, technology anxiety, and technology for social good, attitude towards technology, technology readiness, and technology perception as factors predicting pre-service teachers' acceptance and use of VR in education. Summarily, we found that perceived usefulness is a strong predictor of pre-service teachers' readiness and behavioural intention towards the use of VR in education. Our results show that while technology anxiety may not be considered a predictor of behavioural intention among pre-service teachers, it significantly predicts their readiness to use VR-based technology.

In our model, we hypothesized that technology for social good will predict pre-service teachers' behavioural intention towards the use of VR but our finding stood on the contrary. On attitude towards technology, our conjecturing that it will predict pre-service teachers' behavioural intention towards the use of VR technology was supported by the findings of this study, just as in the case of technology readiness. We also found that based on the data analyzed in this study, technology perception failed to predict the behavioural intention of pre-service teachers but stood out as a strong predictor of their attitude towards, and readiness to use virtual reality technology to support and improve teaching-learning functions. We also found that technology perception has a significant moderating effect on the relationship between pre-service teachers' attitudes towards technology and their behavioural intention to use VR. A similar moderating effect was seen on the relationship between technology readiness and the behavioural intention of pre-service teachers to use VR. Our results further showed that pre-service teachers' understanding and acceptance of the benefit of VR is a strong determinant of their openness and willingness to use VR in delivering instruction in the classroom. Overall, our findings posit that a positive perception of VR technology, such as perceiving it as useful, compatibility with existing technologies, and easy to use, would lead to positive attitudes towards the technology, and create a favourable disposition which, in turn, would enhance pre-service teachers' readiness to use VR.

In our hypothetical model (Fig. 2) and as reflected in hypotheses one and two, we conjectured that perceived usefulness may predict pre-service teachers' readiness and behavioural intention towards the use of VR technology. Our findings revealed that pre-service teachers' view and understanding of the usefulness of VR may have a considerable influence on their disposition and likelihood to use the technology to improve their teaching delivery and enhance learners' understanding. This implies that if teachers-in-training consider VR as a viable educational tool that can enhance their competence and instructional delivery as they become certified teachers, they are very likely to be interested in its use. This line of thought is deeply rooted in and can be justified using the Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975) and the Technology Acceptance Model (TAM) which underpins this study (Abdullah & Ward, 2016; Mailizar et al., 2021). Previous studies on measures of behavioural intention and technology readiness have affirmed that an individual's confidence in the potential benefits of a particular object or technology device usually serves as a positive and enduring impetus for its use by such individuals (Ayanwale, et al., 2022). Our findings equally share semblance with that of Teo et al. (2008), who report that perceived usefulness has a positive and direct influence on pre-service teachers' intention to use technology. It is therefore very likely that preservice teachers will show readiness and a positive disposition to adopt and use VR technology if they are exposed to its immense benefits following sound learning theoretical models because according to Oladeje et al. (2021), what makes the difference when technology is adopted in the classroom is not the technology itself, but largely, how the teacher makes use of it.

On technology anxiety, we speculated that pre-service teachers' anxiety towards the use of virtual reality will predict their readiness and behavioural intention to use the technology. Our findings show technology anxiety may not be a determinant of pre-service teachers' behavioural intention but can influence their state of readiness. Although it would have been expected that anxiety should play a role in their disposition toward VR as already established in the literature based on previous studies (Awofala et al., 2017; Keszey, 2020; Hoeffler, 2003). However, this result is not unthinkable. The majority of the pre-service teachers are of the technophilic generation, whose interest in any activity that is computer and internet-based is on the increase (Okebukola, 2020). As such, it now appears their unwavering interest, increasing dependence, and trust in technology are proving to be an effective antidote to technology anxiety. On the other hand, technology anxiety may have some predictive power on the state of readiness of the pre-service teachers to use virtual reality technology. The feeling of anxiousness about trying a new thing falls within the bell of a normal curve of positive anxiety. As noted by Oladejo et al. (2023) such feelings are not only regarded as normal but are also seen as a necessary drive to achieve success. Thus, it is safe to infer that given the interest of the pre-service teachers in technology (digital natives) and their eagerness to try new tech tools based on perceived ease of use (Wong et al., 2021b), technology anxiety is rather likely to be a necessary force attraction to use virtual reality than been a repellant.

Also, we hypothesized that technology for social good will predict pre-service teachers' behavioural intention towards the use of VR. Interestingly, our findings show that it did not. Given the role of technology such as AI and robots in our everyday activities including teaching and learning (Alhalabi, 2019; Chai et al., 2020; Mandal, 2013), it would have been expected that the social goodness attributable to VR would make it a strong determinant of pre-service teachers' disposition to it. Nonetheless, our finding is suggestive of two things: (1) that the pre-service teachers who participated in this study at the time of data collection had a shallow understanding of the concept of social goodness concerning VR or (2) that this finding is an invitation for further investigation on the perception of users, particularly teachers (pre/-in-service teacher) about the social good of VR technology. Conversely, an attitude which is a major construct in the theory of reasoned action and, which has been adjudged as a major factor affecting an individual's predisposition to a particular thing was found in this study to predict pre-service teachers' behavioural intention to use virtual reality. Our finding aligns with those of previous studies (Ajzen, 2020; Dwivedi et al., 2021; Islam et al., 2013; Rana et al., 2017) that have explored this factor. It affirms that a strong predictive relationship exists between attitudes towards VR and the behavioural intention of future teachers to use this specific technology. Thus, pre-service teachers' overall evaluation and feelings towards VR can influence their beliefs about the effectiveness of the technology as an educational tool, their confidence in using it, and their perceptions of the ease of integrating it into their future teaching practices. Positive attitudes towards technology are likely to result in a higher behavioural intention to use VR, while negative attitudes may act as barriers to adoption. Our finding further highlights the importance of addressing pre-service teachers' attitudes towards technology to promote the successful implementation of VR in education. It suggests that teacher training programs should focus not only on the technical aspects of VR but also on fostering positive attitudes towards technology and building self-efficacy beliefs.

In addition, we explored the relationship between technology perception and pre-service teachers' behavioural intention to use VR in educational settings. While technology perception has been considered an important factor in the acceptance and adoption of educational technologies (Boonmoh et al., 2021) our finding shows that technology perception does not predict pre-service teachers' behavioural intention to use VR. The findings contribute to a better understanding of the complex factors influencing teachers' adoption of VR in the classroom. The integration of VR technology in educational settings has gained attention for its potential to enhance student learning experiences. Pre-service teachers, as future educators, play a critical role in the successful implementation of VR. Thus, understanding the factors that influence their behavioural intention to use VR is crucial for effective teacher training and curriculum development.

Contrary to previous research that suggested a positive relationship between technology perception and the behavioural intention to use technology (Eyyam et al., 2011; Or-Kan & Ahmad, 2018), the findings of this study indicate a lack of predictive relationship between technology perception and pre-service teachers' intention to use VR. These results challenge the conventional understanding and assumptions regarding the importance of technology perception in determining behavioural intention. Several factors might have contributed to this result. One possible explanation is the novelty and unfamiliarity of VR technology. The participants in this study may not have had sufficient exposure or training in VR, leading to difficulties in accurately perceiving the technology's characteristics and potential benefits. On the other hand, their understanding of the complexity (including the technical know-how which is not readily available in most schools) and cost associated with VR implementation in educational settings could have also influenced their perception. There is a possibility that the perceived complexity and cost might be seen as not commensurate with the potential benefits, resulting in a lack of positive perception among the participants, despite the acknowledged advantages of VR technology. These results have important implications for teacher training programs and curriculum development. While technology perception may not directly predict pre-service teachers' behavioural intention to use VR, it does not diminish the significance of training programs. Instead, the focus should shift towards providing pre-service teachers with firsthand experiences and practical training in using VR. Hands-on experiences, demonstrations of successful VR integration, and collaborative learning opportunities can help pre-service teachers develop a better understanding of VR's potential in educational contexts. Furthermore, it is essential to consider other factors that may influence pre-service teachers' behavioural intention to use VR, such as pedagogical beliefs, prior experience with technology, social influence, and institutional support. By addressing these multifaceted factors, teacher training programs can create a conducive environment that encourages pre-service teachers to embrace new technologies like VR.

Furthermore, we hypothesized that technology perception will predict pre-service teachers' attitudes toward using VR. Given our understanding that positive technology perception, such as perceiving VR as useful, easy to use, and compatible with teaching practices, may have both practical and methodological implications leading to more positive attitudes among future teachers towards employing VR in the classroom. Similar to the findings of other studies (Ajzen, 2020; Dwivedi et al., 2021; Rana et al., 2017), we found that there is a strong predictive relationship between technology perception and pre-service teachers' attitude towards the use of VR in educational settings. Findings from previous studies have also suggested that pre-service teachers with positive technology perception are more likely to exhibit positive attitudes toward using VR in education. Their findings suggest to us that to develop positive attitudes toward technology such as VR, pre-service teachers must perceive VR as useful, user-friendly, and compatible with instructional goals for fostering meaningful learning. We also explored the predictive relationship between technology perception and pre-service teachers' readiness to use VR in education. Understanding how technology perception influences readiness to adopt and utilize VR is crucial for the effective implementation of this innovative technology. We found that technology perception has a high predicting power on pre-service teachers' readiness to use VR. This finding also toed the path of previous studies (Dwivedi et al., 2019; Lee 2009; Shanmugham & Ramya 2012; Yaghoubi et al., 2010). Since readiness to use VR in this context would refer to pre-service teachers' preparedness and willingness to adopt and effectively integrate VR into their teaching practices, it is safe to infer that readiness to use VR is an important determinant of pre-service teachers' ability to successfully implement and utilize the technology in their future classrooms. Therefore, there is a high chance that positive technology perception would lead to higher levels of readiness to adopt and utilize VR in the classroom.

Finally, we argue that positive attitudes and readiness reflect a belief in the potential benefits of VR for teaching and learning, as well as openness and willingness to use the technology. While negative attitudes, on the other hand, may arise from concerns or skepticism about VR's effectiveness or difficulties in using the technology and ensuing lack of readiness. The precipitate of these findings concerning the outcomes of previous studies is that teacher training programs must activate mechanisms to address pre-service teachers' technology perception. Addressing concerns and challenges associated with using VR, such as affordability and technical difficulties can help alleviate negative perceptions and foster more favourable attitudes. Creating a technology-enhanced learning environment, adopting technology in the instructional process, and offering support resources such as access to virtual laboratories can also enhance pre-service teachers' confidence and enthusiasm in adopting VR and ultimately contribute to the successful integration of this technology in education.

7. Study implications

The practical implications of this study extend both to Nigeria's educational landscape and to broader contexts. Firstly, for Nigeria, the study emphasizes the necessity of fostering a positive perception of technology among pre-service teachers. To implement VR-enhanced learning effectively, efforts should be directed toward training educators to view technology as a valuable tool rather than an intimidating challenge. This might involve targeted professional development programs, workshops, and awareness campaigns tailored to address any negative perceptions or anxieties. Secondly, the study underscores the importance of addressing technology-related anxieties and concerns among educators. While the direct link between Technology Anxiety and Behavioral Intention might not be significant, the observed connection between Technology Anxiety and Technology Readiness implies that apprehensions could hinder the successful implementation of VR-enhanced learning. Nigerian educational institutions, as well as those in other regions, should consider offering support systems, mentorship, and resources that help educators feel more comfortable and prepared to use VR technology in their teaching practices.

Also, the study's mediation analysis highlights the pivotal role of attitudes toward technology in influencing the intention to embrace VR-enhanced learning. This suggests that interventions aimed at cultivating positive attitudes are crucial. Practical measures could include creating user-friendly interfaces for VR platforms, providing engaging and relevant content, and offering ongoing training and support to ensure educators feel empowered and optimistic about integrating VR into their teaching methods. Moreover, the study's call for a deeper understanding of Nigeria's unique context is crucial. Cultural, socioeconomic, and infrastructural factors can significantly impact the adoption and success of VR technology. Thus, practitioners and policymakers should tailor their approaches to address these specific contextual elements. For instance, initiatives might include developing localized content that aligns with cultural norms and values, addressing accessibility challenges, and working to bridge potential digital divides. Lastly, the collaboration between researchers and practitioners advocated by the study has far-reaching implications. This collaborative effort can be applied beyond Nigeria to other countries and educational systems. By bringing together the expertise of researchers, educators, and administrators, a more comprehensive and effective implementation of VR-enhanced learning can be achieved, grounded in research insights while being adaptable to the practical realities of different educational settings around the world.

8. Conclusion

This study contributes to the ongoing discourse on how teachers, particularly those in training, make decisions about incorporating beneficial educational technologies into their classrooms. The main objective of this study was to examine pre-service teachers' intentions to use VR, which was accomplished through a mixed-method research approach. The research took into account the contextual background of teacher education and the specific parameters embedded within Nigeria's educational system. To ensure comprehensive results, the study incorporated various personal and contextual variables, such as technology perception, perceived usefulness, technology anxiety, technology for social good, technology readiness, attitude towards technology, behavioural intention to use VR, as well as socio-demographic factors. To test the hypotheses, a structural equation model was employed, and the study successfully validated seven out of the ten hypotheses. The findings shed light on the significant factors influencing pre-service teachers' BI to utilize VR and how these factors interact. Specifically, the study revealed that a positive perception of technology has a positive and significant effect on attitude towards technology, which further impacts the BI to adopt VR technology. This implies that pre-service teachers who hold a favourable view of technology are more prone to having a positive attitude towards VR, thereby increasing their BI to incorporate VR technology in the classroom.

Additionally, the study found that the majority of participants possessed abstract knowledge of VR, lacking practical experience or expertise. It was also observed that pre-service teachers who experience anxiety about technology are less prepared to use VR, thereby diminishing their intention to utilize it in the classroom. Importantly, a careful evaluation of the multiple variables addressed in this study revealed that internal factors undeniably play a crucial role in determining pre-service teachers' behavioural intention and subsequent usage of VR in the classroom. This deepened understanding of the requirements for effective teacher education and enables the swift dissemination of information to teacher education programs and professional organizations. Such efforts are vital for facilitating the effective integration of VR in education, considering its recognized importance as an educational concept.

9. Limitations and future work

It is important to acknowledge the limitations of this study. One limitation is that the data collected through the online instrument may have been subject to social desirability bias, leading participants to potentially overstate their beliefs, practices, and attitudes. To obtain more accurate information, future research could consider incorporating observations and interviews alongside self-report measures. Another limitation relates to the use of a singular university. This restricts the generalizability of the findings to a broader population. To enhance the validity of the conclusions, future researchers should aim to include larger and more diverse samples from different educational contexts, allowing for comparisons across various settings. Additionally, the study participants were at diverse levels in the university at the time of completing the online instrument. This variation in level and experience might have influenced how participants perceived the appropriateness and usefulness of VR, as well as their intention to use it. Subsequent studies might want to explore the variations in the responses of the trainee teachers based on their grade level, providing a deeper understanding of how they engage with VR. Furthermore, researchers and practitioners are encouraged to set up studies investigating the effectiveness of interventions where pre-service teachers are exposed to VR-integrated classroom interventions, and VR-enhanced learning in Nigeria. By examining whether this experience enhances their behavioural intention to utilize VR, researchers can gain valuable insights into the potential impact of hands-on VR training in teacher education programs. Considering these limitations, it is crucial for future research to address these concerns and build upon the current findings, thus advancing the current study.

Statements on open data and ethics

The information pertaining to the pre-service teachers involved in this study was kept confidential to ensure their privacy. Additionally, they were explicitly informed that their participation was voluntary, and they had the freedom to withdraw from the study at any stage without facing any penalties. The data from the study is accessible upon request.

Declaration of competing interest

No competing interest.

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