The pedagogical potential of virtual reality head-mounted displays in the training of pre-service history teachers to promote self-directed learning

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Abstract

The arrival of the Fourth Industrial Revolution (4IR) as well as the required and accompanying twenty-first century skills has led the educational system towards a position wherein significant methodological and pedagogical intervention is required in order to modernise the system to better accommodate the needs of the twenty-first century learner. Information and Communication Technologies (ICTs), such as Virtual Reality (VR) and

its associated technologies, like Head-Mounted Displays (HMDs), have the potential to enhance the teaching and learning experiences of pre-service history teachers in virtual learning environments (VLEs). This article seeks to explore the pedagogical potential of VR-HMDs as ICT tools in the training of pre-service history teachers by affording them opportunities to engage with subject matter in VLEs such as a virtual Holocaust Museum, a WW II battle re-enactment and the Pearl Harbour attack. Concurrently, the paper sought to determine if VLEs could promote pre-service history teachers' self-directed learning (SDL) skills through the allowance of these experience-based learning opportunities. The research for this study was conducted at a tertiary education institution within a classroom environment where pre-service history teachers made use of VR-HMDs to achieve specific history lesson objectives. Grounded in constructive and interpretive paradigms, the research further employed a single exploratory qualitative case study design with non-probability purposive sampling and discourse analysis. To a lesser extent, quantitative data was also used, complementary to the qualitative data, in order to better understand the phenomena under investigation. Various data collection instruments, including questionnaires, worksheets, focus group interviews, and field notes, were used to gather data from the 15 pre-service history teachers as participants. The findings indicated that VR-HMDs and VLEs hold a significant positive potential for the teaching and learning of pre-service history teachers, as the advantages of this emerging technology far outweigh its disadvantages. Furthermore, the use of VR-HMDs in teaching fostered SDL skills such as goal setting, self-regulation, motivation, and critical thinking.

Keywords: Virtual reality (VR); virtual reality head mounted displays (VR-HMDs); virtual learning environments (VLEs); self-directed learning (SDL); pre-service history teachers; history teaching and learning

Introduction and background

Post 1994, the South African educational system has been undergoing continuous pedagogical and methodological changes (Crouch & Hoadley, 2018). This transition includes, among other things, to integrate Information and Communication Technologies (ICTs) on a larger scale to not only teach subject content, but to also by and large, equip students with the skills to enhance their knowledge and gather information effectively (Mashile, 2017; Graham et al., 2024). The subject content used for this article consisted of a virtual Holocaust Museum, a WWII battle re-enactment and the attack on Pearl Harbour. These topics were used to explore the pedagogical potential of virtual reality head-mounted

displays (VR-HMDs) in shaping memory retention, enhancing historical understanding and developing self-directed learning (SDL) skills among pre-service history teachers through immersive experiences. The training of pre-service history teachers must also adapt to these changes, ensuring that the teaching and learning of history meet the needs of twenty-first century students (Battaglia & McDonald, 2015; Arek-Bawa & Reddy, 2024). VR-HMDs could theoretically enhance the educational process, thus providing higher quality learning experiences, as pre-service history teachers will have more opportunities to be engaged with the subject matter (Hu-Au & Lee, 2018).

The Fourth Industrial Revolution (4IR)—a twenty-first century movement—has integrated technology into various societal levels, and particularly so in modern classrooms. The problem faced by some educators, however, is that not all subjects have had an equitable and fair shared level of exposure to ICTs in classrooms (Dlamini, 2022). In the twenty-first century, students should take ownership of their learning, cultivate lifelong SDL skills, explore subject content with autonomy, stay responsible and remain adaptive in a rapidly changing world (Dahal & Bhat, 2023). Students should be capable of showcasing SDL skills like collaborating and communicating effectively with others, thinking creatively and critically to tackle new challenges, and continually adjusting to evolving technologies (Mentz & Bailey, 2019). It is these and other twenty-first century SDL skills accompanied by emerging pedagogical tools such as the use of ICTs like VR-HMDs and virtual learning environment (VLEs) that is aimed at the cultivation of lifelong, collaborative and communication driven (Marougkas et al., 2024) experiences to the benefit of pre-service history teachers.

The use of emerging ICTs such as, but not limited to, VR-HMDs and VLEs have become integral to innovative pedagogical approaches (Mnisi et al., 2024). Before understanding the inclusion of mentioned ICTs, it is required to first consider societal changes that further cemented ICTs role in education (Karki, 2019). These changes did not happen overnight, but through continuous experimentation. Ratheeswari (2018) reported that there are numerous approaches when attempting to integrate educational technologies. Studies, as far back as those by Wong and Hsu (2008), show ICT's positive impact on teaching and learning and the advantageous possibilities thereof. Over time, the findings of these earlier studies were further corroborated by subsequent research (Chouthaiwale & Al-Kamel, 2018; Saprikis et al., 2019; Meladi & Awolusi, 2020; Anastasopoulou et al., 2024) to name a few. VR-HMDs, as an emerging ICT tool, can be effectively incorporated into the dynamic educational landscape due to their learner-centred and self-directed learning potential (Jensen & Konradsen, 2018; Lege & Bonner, 2020).

The rapid development of commercially used technologies has coincided with the advancement of instructional technologies, and it is this development that shows the dynamism of modern education, especially post-Covid19, emphasising that ICTs require ongoing evolution and adaption (Hamzah et al., 2024). This ongoing innovation has led educational systems to recognise the benefits of technology in the classroom while minimising its drawbacks (Burns & Graafland, 2018). Educational institutions, after establishing feasible ICT policies, began modernising teaching and learning through the addition of computer laboratories, which remain in use today for their hands-on learning experiences and ability to accommodate diverse student needs (Gunter et al., 2012; Sharma, 2019; Munje & Jita, 2020; Alam, 2021; Anastasopoulou et al., 2024).

The use of ICT as a teaching and learning tool in classrooms varies based on lesson objectives, classroom context and student motivation (Groff et al., 2009; Gómez-Poyato et al., 2022). Due to these factors, careful planning is essential to ensure ICT's effectiveness and to establish the pedagogical and content foundation of lessons (Elmqaddem, 2019; Koenig et al., 2024). As society evolves, so do the students that educators are confronted with, making it crucial for subjects like history to adapt their methodologies to remain relevant (Bloom, Dole & Kowalske 2016; Cytrin, 2018). VR-HMDs, in particular, should be used to support interdisciplinary teaching and learning, preventing educational stagnation (Muller & Young, 2010; Leung et al., 2018).

This article is aimed to explore the pedagogical potential of VR-HMDs as ICT tools in the training of pre-service history teachers by affording them opportunities to engage with subject matter in VLEs. Secondly, to explore the extent to which VLEs foster the SDL skills (communication, critical thinking and metacognition) of pre-service history teachers.

In conclusion, it also requires mentioning that while this article explores the possible potential of the inclusion of VR-HMDs as a pedagogical tool in the training of pre-service history teachers, it does not argue to discard traditional methodologies. This inclusion is done not to discard the old, but rather to find a way in which history education as a whole can be modernised while still drawing the full benefit of traditional methods as Thotse (2021) and Hasan et al. (2023) argue that traditional methods still have immense value and are widely used. Thus, this article seeks to find a balance between traditional and contemporary pedagogies.

Literature review

Modern society is rapidly evolving and can now be described as a digital age due to the extensive exposure to various technologies (Levin & Mamlok, 2021; Lendzhova et al., 2022; Rajput & Sharma, 2025). In this digital era, finding effective ways to entice student engagement is an ever-increasing challenge that could potentially be overcome using ICTs (Levin & Mamlok, 2021; ClassVr, 2022; Anastasopoulou et al., 2024). While technologies such as cell phones and gaming consoles have become more accessible and popular, their integration into education remains limited, while other technologies such as AI, for example, ChatGPT, has taken education by storm, post Covid-19 (ClassVr, 2022; Haleem et al., 2022; Guardiola, 2025). The 4IR with its focus on technological advancement and innovative applications, has led to the development of a distinct process of methodological and pedagogical reform within the educational system. This educational transformation depends on the degree to which ICTs are integrated in fostering twenty-first century SDL skills, for example, critical and creative thinking (Burns & Graafland, 2018). It is these aforementioned and other self-regulatory skills that promote metacognitive processes that will empower students to not only take responsibility for their own learning, but also allow them to formulate strategic plans regarding how they aim to achieve their academic objectives through the promotion of self-motivation.

The methodological and pedagogical reforms during the 4IR, when applied to the study of history, could potentially enhance both teaching and learning experiences for pre-service history teachers by promoting the use of ICTs, such as VR-HMDs (Mannak et al., 2024). Effective reform involves a purposeful and goal-oriented application of ICTs to enrich educational practices. This ICT driven approach is intended to move beyond one-dimensional teaching and learning methods, which are considered inadequate for modern educational needs (Mashiyi & Baleni, 2023). Despite advancements in history education, which have shifted from simplistic to more advanced approaches, some educators still rely on traditional methodologies that offer limited opportunities for developing critical skills (Hasan et al., 2023). Modern history educators face significant challenges due to the complexities of teaching the subject. With reference to the Holocaust, for instance, Gouws (2019:2) is of the opinion that history school teachers find it "complex" to navigate between the controversies and challenges surrounding the Holocaust topic, while keeping personal, professional, historical, educational and societal perceptions in mind. These challenges arise from information overload through various media platforms resulting in history educators' struggling to keep up with advancements in ICT. Such issues impact both pre-

service and in-service teachers' ability to effectively use technology in their teaching and learning repertoire (Köse, 2017; Ciriza-Mendívil et al., 2022).

The Partnership for 21st Century Skills (2009) (P21) Framework offers a clear guide to the SDL skills essential for evaluating the effectiveness of teaching and learning in various subjects, such as history within the 4IR and its move to technology driven classrooms. This framework helps in identifying and fostering critical twenty-first century skills, including those necessary for SDL. By using this overlapping framework, educators can better understand and implement the skills required to enhance students' ability to learn independently and thrive in a rapidly evolving educational landscape.

The P21 Framework (2009) illustrates the twenty-first century learning by outlining essential skills and supporting structures required for a successful modernised classroom. At its core, the framework has three critical skill areas: Life and Career Skills, Learning and Innovation Skills (such as creativity, critical thinking, communication and collaboration), and Information, Media and Technology Skills. It is these three skill areas which are then subjected to and supported by the following educational elements: standards and assessments curriculum and instruction; professional development and learning environment. These educational elements, when combined with the three critical skill areas, show the importance of a modernised ICT educational process to which this paper also prescribes.

The P21 Framework also reveals how its components are essential for preparing students to thrive in modern society. It denotes the fundamental knowledge, skills and abilities that students need to master in order to succeed in their work and lives in the twenty-first century. The P21 Framework emphasises that assessments, curriculum and instruction, professional development, learning environments and twenty-first century standards must be aligned to achieve the desired outcomes and determine the effectiveness of teaching and learning in the twenty-first century (Partnership for 21st Century Skills, 2009). Thus, the P21 Framework offers a comprehensive guide for understanding the essentials of effective teaching and learning in the modern era. It is, therefore, important that history educators tailor these guidelines to find the most effective methods for implementation.

In history education, applying the P21 Framework involves engaging students with real-life scenarios and enabling them to analyse the causes, effects and relationships between historical events. The framework supports this by emphasising the importance of critical thinking and problem-solving skills. Students should use their acquired knowledge

to address contemporary issues, applying historical context to devise innovative solutions. Furthermore, the P21 Framework aligns with the goal of developing students' ability to interpret and analyse multiple perspectives. This capability is essential for SDL and is supported by policy documents such as the National Curriculum Statement in the Curriculum Assessment Policy Statements (NCS-CAPS) (Department of Basic Education [DoBE], 2011). The P21 Framework also underscores the importance of historical thinking and reasoning skills, which are central to history education (Akhan, 2021).

In recent decades, the use of ICTs, have emerged as a significant focus in educational discussions, reflecting their growing role as pedagogical tools in the teaching and learning process (Koehler et al., 2022). The P21 Framework supports this by emphasising the integration of advanced technologies, such as VR-HMDs, to enhance educational outcomes and prepare students for the demands of the twenty-first century (Partnership for 21st Century Skills, 2009). As an emerging technology within the ICT sector, VR-HMDs have garnered significant attention for their potential benefits as pedagogical tools (Han et al., 2021). This attention is garnered due to VR's immersive environments that foster a sense of realism which could in theory, enhance student motivation and support the development of critical thinking skills in the context of SDL. It is this sense of realism that affords students the opportunity to learn through immersive experiences. This notion is further supported through a study by Grewe and Gie (2023) where it was determined that the use of immersive ICTs, especially VR-HMDs resulted in a 23 per cent higher pass rate and a 180 per cent higher student engagement rate due to increased motivation, when compared to those students that make use of conventional online or distance learning approaches.

Thus, VR-HMDs are emerging pedagogical tools within the ICT sector that can be used beneficially within SDL and history education, especially now when South African higher educational institutions have started to take an interest in VR-HMDs as a pedagogical tool (Grewe & Gie, 2023). It is this development and growing interest, coupled with the principles of the Technological Pedagogical Content Knowledge (TPACK) framework that an outline to ICT and as a result VR-HMDs is developed (Mishra & Koehler, 2006). VR-HMDs fit into the TPACK framework through the creation of teaching and learning settings that simulate realistic, immersive environments (often environments not easily accessible to students due to time and distance). Students in a South African history classroom are now, for example, afforded the opportunity to virtually visit German concentration camps such as Auschwitz. It is then that these environments could potentially boost student motivation and help in developing critical thinking skills (Fragkaki et al., 2020).

The integration of ICTs in education through frameworks like P21 and TPACK is ongoing, however, the implementation thereof, especially within South Africa education, is rather lagging (Munje & Jita, 2020). Often the assumption is made that pre-service (history) teachers are well-versed in ICTs, due to modern society being tech-driven. This unfounded assumption stems from the fact that their exposure is often limited to using tools like PowerPoint for aesthetics rather than innovative teaching methods (Fan & Tan, 2019). The effective use of ICTs should first and foremost enhance lessons beyond the effects of traditional stimuli to activate teaching and learning. By activating additional ICT stimuli (visual and auditory), student-centred approaches will be better supported and the development of twenty-first century SDL skills will become evident as students make use of more senses, all of which are paramount to learning (Zyad, 2016). The success regarding the use of ICTs is also determined on the pre-service teachers' disposition to adopt a positive mind-set toward ICT and familiarise themselves with designing blended learning tasks and assessments (Bosch et al., 2022).

In an attempt to discern the extent to which the use of ICTs are used or recommended to be used in South African education, particularly in the history curriculum, it is imperative to examine key policy documents such as the NCS-CAPS (DoBE, 2011) and the White Paper on e-Education (DoE, 2003). Both documents address the integration of ICTs in South African education to a broader sense. However, they do not focus on how specific subject disciplines (that are not technological disciplines by nature) could provide unique benefits to the various subjects that students are expected to master (Padayache, 2017). The White Paper on e-Education (DoE, 2003), at a foundational level, outlines the basic use of e-learning tools like the Internet, CD-ROMs, software and telecommunications for teaching and learning (DoE, 2003). However, it does not specify the categories of technologies that can be effectively used in the classroom (Padayache, 2017). Since the drafting of the document, new technologies with pedagogical potential such as VR-HMDs have come to the forefront. According to Tshimanika et al. (2022), the White Paper failed to meet its goals set for 2013 and as a result, did not fulfil its vision of transforming teaching and learning through ICT.

Although the White Paper serves as an introductory policy, it is not the only document guiding South African educators. The NCS-CAPS, for example, emphasises the importance of using technology responsibly, encouraging the development of critical thinking skills, and promoting the use of ICT to support students' understanding of different sources of information (DoE, 2011). Specifically, the Further Education and Training History

NCS-CAPS encourages history teachers to use visual tools such as videos and films to enhance students' understanding of the past (DoE, 2011). While the NCS-CAPS history curriculum acknowledges the importance of visual stimuli and encourages the use of ICT in the classroom (DoE, 2011), the policy does not provide educators with clear guidelines or resources on how to effectively incorporate these technologies into their teaching and learning methods. Therefore, while both documents provide a foundational indication for ICT integration, they are found lacking in terms of subject-specific guidance and practical implementation strategies.

An additional concern is the lack of subject-specific guidance on the practical application of ICT in South African schools by mentor teachers that adopt the responsibilities as teacher trainers. This presents the schooling system with a significant barrier, particularly for the more disadvantaged schools (Mkuzo & Govender, 2025). These schools and the financially stable schools face challenges in acquiring both the necessary ICT tools as well as the expertise and skills to effectively incorporate them into their classrooms. This deficiency in ICT-related guidance underscores a broader issue of inadequate support and training for ICT integration into the education system, which supports the views of Van Greunen et al. (2021). The inclusion of ICTs in South African schools is often undermined by traditional teacher-centred methods, such as the chalk-and-talk approach and has thus, mostly remained small-scale (Blignaut et al., 2010; Yu & Dlamini, 2025). This is apparent in the South African history classroom, where most history educators continue to rely on conventional teaching methods, which limits the effective use of ICT and impedes the quality of education (Odendaal-Kroon & Poole, 2018). In the same vein, Motumi (2020:57) points out that one of the primary challenges in teaching history in South Africa is the "inability and/or lack of competence" among educators to present the subject in an engaging and meaningful way that meets the needs of all twenty-first century students irrespective of their rural or urban backgrounds (Mkuzo & Govender, 2025). This continued reliance on outdated methods not only hinders the effective use of ICT, it also compromises the ability to deliver relevant and dynamic history education to modern students.

An additional challenge identified by Adukaite et al. (2016) and Pakdaman-Savoji et al. (2019) is that some South African educators, including history educators, primarily use ICTs for aesthetic purposes, rather than to apply it for pedagogical purposes. While this attempted use of ICTs can be applauded, it does not necessarily develop twenty-first century skills when used in this manner (Aslan & Zhu, 2016; Padayachee, 2017).

Padayachee (2017) underscores that simply providing technology is insufficient without proper training on its effective integration into the teaching and learning process. Adukaite et al. (2016) further argue that an educator's knowledge and understanding of ICTs as pedagogical tools directly impacts their effective use, resulting in varied implementation across history classrooms, with some educators being more familiar with ICTs in educational settings than others.

While a lot of the challenges and advantages with regards to the use of ICTs and by implication, VR-HMDs have been alluded to within a South African context, it requires mentioning that pre-service history teachers at tertiary institutions in South Africa do receive some ICT training, however, is often not as comprehensive as programmes in other countries (Maphalala, 2021; Ramnarain et al., 2021). In addition, Banda et al. (2020) point out that due to insufficient ICT training, history teachers at high school level feel less confident when required to incorporate ICTs when starting their teaching careers at schools.

The educators at tertiary institutions attitudes are major predictors of the use of new technologies in instructional settings, and can therefore, not be underestimated (Ogegbo et al., 2024). Bansa (2020) cautions that the relationship between educators' perceptions and beliefs about ICT and its practices is complex. Factors outside educators' control were identified by Jošanov (2008) which affect the adoption and incorporation of ICTs. These factors, to name a few, are: institutional culture; leadership; curriculum; assessment programmes and financial constraints (MacDowell et al., 2025). While these external factors are influential, educators at tertiary institutions still have significant control over how technology is practically used within the training of pre-service history teachers.

The concept of VR can be traced back to the 1960s (Renganayagalu et al., 2021), however, earlier attempts at creating realism in non-physical realms date back to the nineteenth century. Artists created panoramic 360° murals to immerse viewers in the scenes they depicted. Additionally, Charles Wheatstone's 1838 research showed that the brain merges two-dimensional images from each eye (Cavaco et al., 2025), leading to the use of stereoscopic images. The View-Master stereoscope, patented in 1939, became popular in virtual tourism and is considered a precursor to modern VR-HMDs like Google Cardboard (Virtual Reality Society, 2022). As technology advanced in the twentieth century, improvements in computer and electronics further developed the ability to stimulate human senses (ABC News, 2015; Virtual Reality Society, 2022).

Over the course of the last decade VR has experienced an increase in popularity as an entertainment tool due to competition in affordability and varied hardware, with VR-HMDs becoming the main device (Renganayagalu et al., 2021). These headsets cover the user's field of vision and use head-tracking technology for navigation (Specht et al., 2021). VR-HMDs create stereoscopic vision by showing offset images to each eye, often using a single screen with a divider (Ogegbo et al., 2024). These screens simulate the natural field of vision using special lenses and tracking technology (Virtual Reality Society, 2022). With built-in audio and real-time visual updates, VR-HMDs enhance immersion and simulate real-world experiences (Baker et al., 2023). The Oculus Rift, introduced in 2012, boosted VR-HMD use with its affordability and quality (Concannon et al., 2019), leading to many administrators and private companies seeing the advantageous applications thereof in education and training (Renganayagalu et al., 2021).

VR-HMDs have as a result, grown significantly in various fields, including education, health, and engineering (Checa & Bustillo, 2020). The benefits are vast, particularly in providing visualisations not possible in traditional classrooms that stimulate deeper understanding through immersive experiences (Hicks, 2016; Villena Taranilla et al., 2022; Ghosh & Ravichandran, 2024). VR-HMDs, popular in gaming, have proven effective in the field of education in aviation and medicine, with research showing higher performance in students using VR-HMDs in engineering (Alhalabi, 2016). In history education, VR-HMDs can also be beneficial as shown by the research of Yildirim et al. (2018) and Victor (2023). One, if not the most important, benefit of VR-HMDs is that it affords the user the opportunity to regard themselves as part of the environment which then increases their interest and as a result, their motivation to engage with the content. Additionally, the use of VR-HMDs visualises historical events, for example Pearl Harbour, and places such as the Holocaust Museum, which would otherwise be extremely difficult to impossible for some to see. Moreover, studies showed that parents believe VR helps students develop empathy and gain new learning opportunities (Aubrey et al., 2018). Moreover, VR offers various benefits such as immersion, improved perspective-taking and enhanced engagement with the content being experienced (Wang, 2018; Villena Taranilla et al., 2022). It promotes self-regulated learning, critical thinking and motivation, while also helping students develop cognitive, affective and psychomotor skills. Additionally, VR-HMDs can aid teacher professional development by providing engaging simulations in a risk-free setting (Advanced Micro Devices [AMD], 2017; Capatina et al., 2017; Ghosh & Ravichandran, 2024). The immersive nature of VR makes it particularly effective for experiential and constructivist learning, due to it significantly impacting cognitive perceptions of reality

(Makransky & Petersen, 2021). This makes VR-HMDs a valuable tool in education, potentially improving outcomes, motivation and student engagement, especially in subjects like history where it fosters relatable learning experiences (Lege & Bonner, 2020; Horváth et al., 2024).

While VR and HMDs offer numerous benefits in education, they also present certain challenges and limitations as ICT teaching tools (Fernandez, 2017). The Oculus Rift, for example, has been discontinued which serves as an indication that constant upgrades are required to prevent the technology from becoming outdated. The excessive use of VR could desensitise students and reduce its progressive impact on learning (AMD, 2017) and academic development (Fiani et al., 2024). Research by Aubrey et al. (2018) on the commonsense organisation into VR, found initial parental scepticism about VR fostering empathy, though opinions shifted positively for those whose children used VR. Health concerns have also been established when using VR-HMDs, with Aubrey et al. (2018) and Milanesi (2016) and Mon-Williams (2017) highlighting the unknown long-term effects on children, advocating for moderation and supervision. VR-HMDs' proximity to the eyes could lead to eyestrain and headaches due to visual disparity (Mon-Williams, 2017; Renganayagalu et al., 2021). Additional potential health issues include dizziness, anxiety, nausea and blurred vision (Kaleci, 2017).

When exploring VR-HMDs in history education, numerous VR resources like Avantis World, ClassVR and various VR history apps are available on Google Playstore that can be utilised, each with its own cost involved. When specifically looking at Avantis World, used in this research, as an example, we find that it is an online platform divided into different zones, or 'lands', offering immersive VLEs for students to explore independently. These VLEs allow students to discover, investigate and conduct research as though they were physically present at the location. In addition to the immersive experience, Avantis World provides VR lesson plans for their different zones, which include teaching strategies and assessment methods. Specifically, for history education, the platform features the "Trip Through Time Land", covering various NCS-CAPS related topics such early civilisations (The Ottoman Empire, the Middle Ages and the Taj Mahal), the age of exploration (Christopher Columbus, Colonialism and the Black Death), the age of revolution (Europe in the Napoleonic Era, the Industrial Revolution and the Gold Rush) and the modern world (a Jewish Ghetto, Civil Rights Movement, D-Day Landing, Life in Concentration Camp, Pearl Harbour and the virtual Holocaust Museum (accessed through ClassVr specific software). These resources enhance learning by creating interactive and engaging

experiences for students. These experiences are supported by MacDowell et al. (2025), where the author highlights the transformative potential of VR-HMDs in teaching history.

Research design and methodology

A predominately qualitative research design was applied with a minor incorporation of quantitative data to support the qualitative findings. The method of investigation used was that of a single exploratory case study. The focus was on exploring the potential of VR and its application through VR-HMDs in the training of pre-service history teachers and the development of their SDL skills. In informing and guiding the research design a mixed paradigmatic framework combining both the constructivist and interpretivists paradigms were used. The constructivist paradigm, as outlined by Jagtap (2017), allows participants to actively engage in constructing and acquiring knowledge, encouraging life-long learning. This approach was particularly useful for the current study, as it allowed the participants to derive meaning from their hands-on experiences with VR-HMDs in history education (Waring, 2012). The constructivist approach is enriched by the interpretivist paradigm, which emphasises understanding the individuality of participants, acknowledging their backgrounds, experiences and opinions (Maree & Pieterson, 2016). Interpretivism helps provide a deeper understanding of how participants' subjectivity shapes their experiences and perceptions, offering a more comprehensive view of their reality within the broader social context (Maree & Pieterson, 2016).

Population and sample

From a population of 30 second-year pre-service history teachers at a tertiary education institution, a purposive sample of fifteen participants were drawn, who were from diverse cultural backgrounds and represented different gender identities. These second-year pre-service history teachers were specifically chosen because their stage of teacher training makes them more receptive to innovative teaching approaches. It is noted by Darling-Hammond et al. (2020) that students in their mid-stage of teacher training are often more adaptable and willing to engage in pedagogical innovation. This is because they are still forming their professional identities and are encouraged to explore diverse teaching and learning approaches. In adhering to ethical practices, all participants were provided with voluntary consent forms and could withdraw from the research process at any stage. Moreover, all elicit responses were also provided voluntarily. Thus, the final group of participants were fully informed of the research process; the manner in which research would be conducted and their roles within the process.

Data collection and analysis

In the data collection and analysis process, the sample of fifteen participants shared their opinions, attitudes, knowledge and experiences regarding VR-HMDs within pre-service history teacher training.

Tools for data collection

The data was collected using data collection tools such as open-ended questionnaires, Kahoot quiz online questionnaire application, worksheets and semi-structured focus group interviews. Additionally, observational field notes were used to gauge participants' attitudes toward the study. Participants were placed within multiple VLEs and accessed these VLEs using VR-HMDs. Both the hardware (two headsets and controller) and software (Avantis World and additional VLEs) used was provided by ClassVR. Two participants entered different VLEs at the same time (they were at different stages of the researching process). Within these VLEs they had to walk through a virtual Holocaust Museum, engage with exhibits, provide feedback on their experience and eventually answer open-ended questionnaires and participate in semi-structured focus group interviews. To minimise any potential physical harm, an open-space was created for the participants to safely move around with most movements within the VLE being managed using a controller that they themselves had control over. These activities that the pre-service history teachers participated in were intended to show how VR-HMDs can be introduced to history education and how it can be used as an explorative activity aiming to develop content knowledge and SDL skills.

Method of analysis

According to Flick (2014) and Creswell (2014), qualitative data analysis revolves around the interpretation of linguistic and visual information (data) to answer the study's research questions. Furthermore, Flick (2014) emphasises the importance of analysing both explicit content as well as the underlying meaning of responses. Thus, this qualitative method of analysis relies on interpretation skills as a central feature to understanding qualitative data within a thematic categorisation where responses where transcribed verbatim to accurately categorise recurring themes (Hill et al., 2022).

While qualitative data was used as the primary source of data, limited amounts of quantitative data was also collected and analysed. As suggested by Grosser (2016), this

quantitative approach was utilised to determine patterns, means and a standard deviation from the participant responses.

Qualitative data

Qualitative data was collected through an open-ended questionnaire, paper-based worksheet, focus group interviews and field notes—all of this took place after participants entered the VLEs using VR-HMDs. The open-ended questionnaire explored participants' baseline knowledge, backgrounds and attitudes towards ICTs and especially VR. Most participants had a common experience in the use of ICT tools like laptops, tablets and cell phones and academic platforms such as Efundi, however, few had ever used VR-HMDs and none engaged with VR as an educational tool. Despite this, participants showed enthusiasm and curiosity about VR in education, and not just as a tool for commercial gaming. This lack of VR experience through participating in this study also encouraged participants to reflect critically on ICTs they have been exposed to and the way these ICTs have been used to align and promote SDL skills.

Following this initial researching phase, participants completed a paper-based worksheet centred around the VR experiences from immersive VLEs that they have been exposed to. These VLEs included a virtual Holocaust Museum, a WWII battlefield and Pearl Harbour. This paper-based worksheet focused on how content was experienced and understood and if the experience of VR contributed (in their opinion) to a deeper understanding. Most of the participants believed that the visual, immersive nature of this VR experience deepened their understanding, while also eliciting an emotional response that improved their empathy towards those involved and the topic as a whole, while it also enhanced information retention This is proven by the following opinions:

> *"Definitely change people's perspectives of what they think… and I think that would be very, very important for them to the learning process as well".*

> *"It made me realise that war is not the answer to any problem and that we should avoid it at all costs".*

> *"…they linked together and helped me learned better about history" and ""Yes…It was like an experiance (sic) in their shoes".*

Some participants described a sense of being present in the VLE as if it replaced reality, which contributed to developing historical consciousness and more meaningful learning. It is these opinions expressed as follows:

"It's the fact that we got the feel of what it was like…" and "It added to my knowledge by actually taking me to the event…", that adds to the value of VR-HMDs within history education.

In the final phase of gathering qualitative data, semi-structured focus group interviews revealed that most participants found their first VR-HMD experience enjoyable and believed it could benefit the emotional engagement that students could have with historical content. Approximately half of the participants were also of the opinion that VR-HMDs could play a pivotal role in connecting pedagogy and content knowledge while developing SDL skills. While the responses were mostly positive, participants did not shy away from the concerns and limitations they could foresee using VR within education. These concerns and limitations include cost, technical issues, unfamiliarity with VR and logistical challenges like load-shedding. Nevertheless, most participants agreed VR was more feasible for tertiary education as many expressed a strong desire to use it in their future classrooms. They also believed that consistent exposure to VR could improve motivation, goal-setting, critical thinking, and overall engagement in teacher training.

Quantitative data

Quantitative data was collected through pre- and post-test VLE questionnaires, with additional input from a Kahoot quiz after the exposure to the VLEs. The Kahoot quiz tested the participants content knowledge after being exposed to the virtual Holocaust Museum, WWII battle re-enactment and Pearl Harbour VLEs and provided the researcher with numerical data regarding their results. These data collection instruments aimed to substantiate the qualitative findings by capturing participants' knowledge and perceptions around ICT, VR-HMDs and SDL through mean scores. To condense the data gathered, the questions used have been clustered for this paper. The first cluster of questions focused on ICT-related competencies, it is here where most participants indicated that they do have a solid understanding of ICT (mean score 4.3), however, they also have a slightly lower grasp of VR-specific concepts (mean score 3.5). This lower score, when focusing on VR, is likely due to limited prior exposure to the technology as an ICT. Nonetheless, most participants still showed positive attitudes. The following cluster of questions looked at SDL skills, and it is here where participants reported confidence in critically questioning, problem-solving, and open-mindedness (mean scores of 4.0–4.4), thus indicating a strong understanding of what is meant when SDL principles are in question.

The post-test VLE responses revealed a clear willingness to adopt ICTs—especially VR-HMDs—in history education and especially within their own teaching and learning experiences, with the highest mean score of 4.6. This willingness suggests that exposure to immersive technologies positively influenced participants' beliefs and attitudes regarding their educational merit. Participants further highlighted the interactivity and immersive nature of VR as a key beneficial educational tool, while also promoting better information recall and conceptual understanding (mean score of 4.5) and the development of SDL skills (mean score of 4.2). Moreover, 66.6 per cent of participants believed that VR technologies could extend beyond tertiary education into school settings, this further reinforced the broader applicability of VR-HMDs in enhancing historical understanding and fostering SDL skills.

Findings and discussion

This study, which is part of a larger study, explores the pedagogical potential of VR-HMDs when incorporated in the teaching and learning of pre-service history teachers. The empirical research conducted revealed an overwhelmingly positive attitude from the participants towards VR-HMDs as a potential educational ICT in history teaching and learning. This result is confirmed by Yildirim et al. (2018) and Victor (2023) who found that history students welcomed VR technologies as a tool to improve their learning experiences. The participants emphasised that they believe the inclusion of VR-HMDs could potentially lead to heightened student engagement, improved student motivation, deeper historical understanding and the promotion of SDL skills. These potential advantages identified by the participants of this study are supported by the findings of Wang (2018), Villena Taranilla et al. (2022), Horváth et al. (2024), Lampropoulos & Kinshuk (2024), Ogegbo et al. (2024) and MacDowell et al. (2025), who conclude that students that are engaged with VR experience increased motivation, foster a positive attitude to learning and enhanced understanding. A key factor as to why these studies delivered similar findings, with a special focus on positive attitude and improved motivation, is due to the fact that the participants found the simulations enjoyable, immersive and transformative.

The findings of the study also determined that VR-HMDs offer experience-based immersive learning environments in which learning can take place—a conviction that is supported by the research of Ghosh and Ravichandran (2024). It is these learning environments that cater to a diverse range of learning preferences. Furthermore, the participants opined that the VLEs used facilitated deeper connections between historical

subject content knowledge and pedagogical strategies. It is then that these beliefs of the participants that VLEs have the potential of enhancing memory retention and fostering historical insight. Moreover, these VLEs provided a unique first-person perspective that encouraged critical thinking and supported a more student-centred approach to learning. It is these advantages that underscore the necessity of transformative educational ICTs such as VR within the teaching and learning process. It is within the use of these transformative ICTs such as VR where SDL skills such as independent goal-setting, reflective thinking and self-regulation are better developed.

Furthermore, it is these advantages and the added emotional engagement that students may have with subject content through VR that allows for a teaching and learning experience that aligns with constructivist learning principles (Aubrey et al. 2018), where learners actively construct meaning through authentic experiences. The immersive nature of VR allowed students to explore historical environments and narratives in ways that traditional methods cannot easily replicate, supporting both cognitive and affective dimensions of learning. Thus, the use of VR in history classrooms, while not providing tactile interactions, still afford students a broadened access to the way in which content can be engaged with. This finding is confirmed by Stephan et al. (2025). While tactile interactions are not yet readily available in the use of VR-HMDs, the technology does still provide a sense of realism through auditory and visual stimuli.

However, this article also acknowledges several limitations that must be addressed for effective implementation. The high costs associated with acquiring and maintaining VR technology, coupled with technical difficulties and infrastructure issues such as load shedding, create real barriers within the South African context. While these limitations alone are worrisome, it is also found that the scarcity of South African curriculum-aligned historical VR content also plays a role in limiting VR as an educational tool. These limitations mentioned above were also identified Ghosh & Ravichandran (2024) and Mnisi et al. (2024). Additionally, some participants identified that they experienced some eye-strain and motion sickness, two unfortunate qualities that do pose health concerns. These health-related limitations did, however, also appear in other similar studies, especially those of Mon-Williams (2017), Renganayagalu et al. (2021) and Voinescu et al. (2025). Nevertheless, while these limitations truly require consideration, they did not significantly detract from the overall positive reception and enthusiastic attitude towards VR in history education expressed by participants.

Despite these limitations, most participants expressed a strong interest in the continued use of VR-HMDs in their teacher training programmes. They recognised its value not only for academic development, but also for enhancing professional preparedness when it comes to the use of modern ICTs and the development of their SDL skills. Thus, the potential of VR (VR- HMDs) as an ICT with its SDL advantages, improved attitude and motivation, deeper understanding and global accessibility outweigh any financial fears that institutions may have regarding VR.

The findings further supported by Lege and Bonner (2020) that VR-HMDs hold considerable potential as a powerful educational tool in history teacher training. Institutions with the capacity to invest in VR-HMDs are encouraged to explore its integration, as it offers innovative, learner-centred experiences that align with contemporary educational goals and foster deeper, more meaningful engagement with the past. It is also by actively engaging with this technology and the companies that produce the VR apps, that more curriculum related content will be created and thus, eliminating another limitation thereof.

Conclusion and recommendations

This study explored the pedagogical potential of VR-HMDs in the training of pre-service history teachers and the development of SDL skills, emphasising both the promising benefits and the challenges associated with its implementation. The findings revealed that VR-HMDs significantly enhanced cognitive processes such as memory retention and reflective and critical thinking. By immersing participants in historically themed VLEs, the technology deepened their understanding of historical events, fostered empathy and contributed to the development of historical consciousness. Moreover, the immersive nature of VR-HMDs supported a more engaging and enjoyable learning experience promoting active participation and strengthening the SDL skills of the pre-service history teachers.

Furthermore, the study emphasised and recommends the importance of ensuring equitable access to VR technology, particularly for underprivileged schools, to allow all learners to benefit from this innovative educational tool. Based on the findings of this study, it is necessary to foster collaboration between key academic stakeholders in developing more historical VR content and providing appropriate training and resources for educators. This collaboration is important in seeking answers and solutions to the high cost of VR equipment, technical issues related to hardware and software, the scarcity of high-quality

historical VR content and the potential health concerns. It is further recommended—within history education studies—that the use and effect of VR gamification as a pedagogical tool should be researched in future. By addressing these challenges and taking proactive steps, VR-HMDs can be successfully integrated into history education, providing a modern and impactful approach to teaching and learning. By continuing to introduce and advance technology in education, the learning potential will be maximised, especially for the twenty-first-century history student. This maximisation of pedagogical potential will take place even more so if ICT introduction is coupled with immersive learning opportunities, such as those provided and showcased by VR-HMDs and VLEs.

In conclusion, the integration of emerging technologies such as VR-HMDs within the professional training of pre-service history teachers has the potential to revolutionise the teaching and learning of history by experiencing immersive and interactive learning environments that provide personalised learning experiences. A key point that requires emphasising as a final thought is that of Stephan et al. (2025), wherein the opinion is expressed that should VR be introduced to teaching and learning consistently, it has the potential to democratise education and provide supplementary experiences to students that would otherwise not have access to the information and / or locations being studied. Thus, the use of VR-HMDs provides a sense of enrichment to history education by presenting a modern world perception for a historical past.

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