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The Promise of the Fourth Industrial Revolution: Unleashing the Potential of Virtual Reality in the Teaching of History Curriculum

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Abstract

The growing economic viability of virtual reality has made it possible for educational institutions to use the technology in their teaching. The growth of mobile networks and the spread of digital gadgets, which are more widely available to teachers and students, support this. Notwithstanding the known critical role of Virtual Reality in the teaching of engineering and medical education, its use and application in history curriculum stays an unchartered territory. This paper interrogates the affordances of VR in education with a slant towards its use in history teaching. Understanding how the adoption of the fourth industrial revolution and the affordances of virtual reality in education could unlock new avenues in the teaching of history curriculum. Thus, by exploring the potentialities of VR in the teaching of history, the paper hopes to lay a foundation on which social science researchers can further explore how the affordances of VR improve the teaching fraternity especially so in developing countries. The paper advances the argument that VR is not only useful in engineering and medical education but also to social science in general and history curriculum in particular. This study supplies insights about this underexplored territory through assessing the functional implications of virtual reality in the teaching of history curriculum.

Keywords: *Affordances; Fourth Industrial Revolution; History Curriculum; Virtual Reality*

Introduction

Investigations exploring the value of technology-assisted education as a pedagogical method were conducted for about 50 years (Hamilton, McKechnie, Edgerton, & Wilson, 2021). Virtual reality (VR) is being applied and used more often in the teaching of physical sciences. Notwithstanding the known critical role of Virtual Reality (VR) in the teaching of engineering and medical education, its use and application in history curriculum is still an unchartered territory. Recent studies have begun to untangle the interplay between education and VR as the international wave of change provided by the fourth

industrial revolution (4IR) has introduced technology as a benchmark for quality education (Bogiannidi, Southcott & Gindidis, 2023; Yende, 2021). Governments all over the world are trying to push the digitalisation of the education sector and to further align schooling with the requirements of the digital era (Langthaler & Bazafkan, 2020). This effort suggests the embracing of the 4IR in education (Brown-Martin, 2017). However, as the use of educational technologies continues to gain speed and the area of education is constantly transformed by it, educators and institutions are searching for fresh approaches to incorporate digital tools into the learning process (Dick, 2021). The expansion of the digital age in education is not a new phenomenon; nonetheless, the uptake varies from nation to nation depending on the amount of internet access. According to recent studies, the 4IR has existed for many decades, but emerging nations have not yet fully embraced it (Bogiannidi et al., 2023; Joosub, 2023; Ogbonna, 2022). While developing nations in Africa are still having difficulty transforming their educational systems to be more digital, developed nations in the west have made incredible strides in integrating digital tools into teaching and learning. When implementing various curricula, teachers are motivated to reinvent and rethink new pedagogical techniques by the introduction of the 4IR in the educational spectrum. In addition to the online pedagogical methods made famous by the COVID-19 outbreak in the educational sector, virtual reality is another new instructional instrument that has popularity in the engineering and medical sectors. Virtual reality has been around for a while, but according to Ogbonna (2022), it has only recently been used in education, particularly in underdeveloped nations. As a result, research into how virtual reality technology might be used in education is still in its infancy, particularly in Africa. Its applications in history and the social sciences in general are understudied. Considering this gap, this paper argues for the adoption of the 4IR and the use of virtual reality not only in hard sciences as is the norm in developed countries but to extend that to the teaching of history, one of the areas underrepresented in the use of virtual reality (Hamilton et al, 2021). So far, however, there has been little discussion about the use and application of VR in the teaching of the history curriculum. This paper interrogates the affordances of VR in education with a slant towards its use in history teaching. By exploring the potentialities of VR in the teaching of history, the paper hopes to lay a foundation on which social science researchers can further explore how the affordances of VR can improve in the teaching of the history curriculum especially so in developing countries. The study is guided by the following objectives:

1. To explore the affordances of VR as a tool in history education
2. Establish areas where VR is useful in the teaching of history curriculuim.

In the next section, the article briefly discusses the emergence of the 4IR in education, thereafter it conceptualizes VR followed by the interrogation of its affordances as a tool in education. The paper then shows areas and apps developed elsewhere to teach concepts in history. The last segment offers insights on policy and practice on VR to round up the paper.

The Fourth Industrial Revolution and Education

The fourth industrial revolution (4IR) can be defined as the transformation to novel systems, which bring together the physical and digital technologies to an increasingly interconnected population of active users (Tripathi & Gupta, 2021). From this definition, the paper can briefly describe 4IR as the vital interaction between humans and machines characterized by the fusion of the digital, biological, and physical worlds, as well as the growing utilisation of new technologies such as but not limited to artificial intelligence, cloud computing, robotics, 3D printing, the Internet of Things, advanced wireless technologies, big data, cybersecurity, block chain, and robots. According to Yusuf and Walters (2020), the 4IR started in the early 2000s and has the potential to create the future, wherein educational tasks are made easier. As argued by Haleem, Javaid, Qadri and Suman (2022) that these digital technologies have made a change in thinking in the entire education system, not only a knowledge provider but also a co-creator of information, a mentor, and an assessor. However, while effective implementations of new technologies have the potential to transform the way teachers teach and how students engage in learning through the use of smart devices (Bogiannidi et al, 2023), many schools in Sub- Sahara Africa lack

readiness for the age of digitalization in terms of insufficient infrastructure, structural underfunding and lack of skills as well as preparedness among teachers (UNESCO, 2015 cited in Langthaler & Bazafkan, 2020). For instance, a study by Chomunorwa, Mashonganyika and Marevesa (2023) reports that South Africa, like other sub-Saharan African countries, has experienced economic problems since the turn of the millennium that have led to challenges in digital technology investment efforts, resulting in a serious digital technology deficit in the region. In the same study, they report that in Zimbabwe, for example, the ratio of learners to computers was reported to be 1:32 in 2019. The lacks and deficits were earlier confirmed by Langthaler and Bazafkan (2020) who revealed that internet connection in schools is reported to cover 78 % of primary and 100 % of secondary schools in Botswana, while coverage extends to only 5 % and 15 %, respectively, in Zambia. Joosub (2023) also reports that the World Bank data from 2021 reveal that less than 50% of the population in sub- Saharan Africa has access to electricity of which in rural areas, the average is only 28.5%. Despite these known challenges, scholars have shown the potency of the 4IR in education (Bogiannidi, et al., 2023, Chomunorwa, et al., 2023; Joosub, 2023) of which they argue that technology can support students to construct knowledge, develop skills and to become self-regulated learners. As argued by Joosub (2023) that the 4IR provide access to quality educational resources, support remote learning and enhance the overall educational experience for learners, especially in Africa's most rural and under resourced communities. In support, Chomunorwa, et al (2023) contend that the digital transformation of education involves a shift from traditional pedagogy to more learner-centered, technology-driven learning with enhanced teaching and learning experiences. From these studies the article construes that technology can play a key role in addressing many of the barriers to education that exist in Africa by transforming how learning and teaching are conducted. As explicitly pointed out by Haleem, et al (2022) that the introduction of new technology-assisted learning tools such as mobile devices, smartboards, MOOCs, tablets, laptops, simulations, dynamic visualisations, and virtual laboratories have altered education in schools and institutions where the Internet of Things is proven to be one of the most cost-effective methods of educating young brains. The study therefore argues along Stutchbury, Ebubedike and Chamberlain (2023) that education policies across sub-Saharan Africa require teachers to change from being transmitters of knowledge to facilitators of learning by adopting the affordances of the 4IR. Considering recent development in the adoption of the 4IR, it is becoming extremely difficult to ignore the existence of Virtual Reality (VR). VR is one of the educational tool ushered in by the 4IR which teachers must use in the teaching of history curriculum though its affordances in social sciences, the loci of the current study, remains an unchartered territory. As such, despite the importance of VR, there remains a paucity of evidence on its use in the teaching of the history curricula

Virtual Reality

The digitalisation of education powered by the 4IR is gaining currency across the globe. Central to the entire discipline of the 4IR is the concept of VR. As observed and explicitly defended by Dick (2021) that VR technologies are a promising addition to the growing field of education technology because of their immersive experiences, their ability to share information in new and engaging ways, and their potential to offer virtual experiences that expand access to educational opportunities that would otherwise be limited by cost or physical distance. In this study, the term Virtual reality is defined as a simulation of a real or imagined environment that can be experienced visually in the three dimensions of width, height and depth and that may additionally provide an interactive experience visually in full real-time motion with sound and feedback Ogbonna (2022). Seen this way, VR is a computer-simulated, game-based learning environment, which appears real and gives learners the opportunity to interact with the learning materials and share learning experiences with both their teachers and other learners. From the definitions, VR emphasizes the three most important properties namely immersion, interaction and imagination (Hamilton, McKechnie & Edgerton, 2021; Häfner, Häfner & Ovtcharova, 2013). As explained by Hamilton et al (2021) following Sherman and Craig (2003) that there are constituent elements that must underpin the VR experience, leading to the life-like belief of the virtual environment.

These include the requirement for VR to be immersive, in that the user's cognitive processes create a sense of presence and involvement in the virtual realm, often with reduced awareness of what is going on around them in the actual world. The virtual environment should also have level of interaction, allowing users to change the environment and experiment with different variables. This might entail communicating with real-world users, virtual avatars, or even other real-world users inside the components. As a result, VR is made possible by a variety of input and output devices, which allow for a two-way exchange of information between the user and the virtual environment (Byles, 2017). Numerous studies agree that while VR has been around for a while, its application in education is still relatively new in underdeveloped nations and requires more research (Boyles, 2017; Hussein, 2015; Ogbonna, 2022; Ogbuanya & Onele, 2018). The financial implications and affordability of VR have been major obstacles to its broad adoption. As said by Hussein (2015), VR was out of reach for educational institutions at the time, but things have changed since then because the technology is now more advanced, less expensive, more available than ever before. Boyles (2017) supports that claim and contends that one of the major obstacles to the adoption of VR in education was its prohibitive cost. But with the introduction of Google Cardboard, the public was first made aware of the fact that any smartphone from this generation could be transformed into a VR machine with the aid of a head-mounted device (Hussein, 2015). As a result, low-cost virtual reality devices powered by smartphones have been widely produced and sold, making virtual reality technology accessible to the public. That supports the notion that VR technology will revolutionise education, particularly in the fields of science, technology, engineering, and mathematics (Dick, 2021; Ferdinand, 2019; Ferdinand, Soller, Hahn, Parong & Göllner, 2023). What then are the affordances of virtual reality in education in general and history curriculum in particular? The article argues that if those in hard sciences can employ virtual reality for laparoscopy, temporal bone surgery and even dental training, the same can be done in the history curriculum.

The Affordances of VR as a Tool in History Education

The study examined the VR's affordances. The findings backed the idea that the success of a number of widely used consumer products, including the Google Cardboard, Daydream View, Oculus Rift, HTC Vive, Samsung Gear VR, Playstation VR, and Microsoft HoloLens, is proof that technological advancements have finally solved a lot of the issues that had previously doomed VR. The current study concurs with Joosub (2023) that digital education must be more widely accessible to African teachers and pupils because of the expansion of mobile networks and digital gadgets in sub-Saharan Africa. This is only achievable when data and technology are more readily available, more affordable, and more user-friendly. The article argues that digital education can help close gaps in information access, especially for the disadvantaged who are often unable to attend school due to physical limitations. As a result, when there are no trained teachers available in the students' immediate physical area, digital education can improve their life by broadening their perspective of what is possible and linking them to learning resources. Based on these presumptions, the paper argues that VR has numerous special advantages when utilised in education (Hussein, 2015) because of its immersive character, capacity to communicate knowledge in novel and interesting ways, and potential to provide virtual experiences that can overcome obstacles related to cost or distance. According to studies, incorporating VR into the classroom gives teachers a new tool and enables them to connect with more pupils (Dick, 2021; Ferdinard, 2017; Ferdinand, et al., 2023). Thus, the goal of VR is to improve, excite, and stimulate students of events while also enabling them to engage in experiential learning. Dick (2021) adds that what makes VR in education more alluring is that it can be used to simulate experiments that have proven difficult to conduct in traditional instructional environments, teach students about safety procedures, and allow learners to practice procedures without the risk involved. Reduced distractions during remote learning are another benefit of fully immersive VR experiences, which helps students focus throughout sessions (Dick, 2021). That shows that virtual reality's immersive qualities may help students tune out outside distractions so they can concentrate on their learning goals. Numerous VR research have proved that when utilising

immersive virtual reality, students are more concentrated and focused (Boyles, 2017; Hussein, 2015; Ogbonna, 2022; Ogbuanya & Onele, 2018).

Considering the, VR offers teachers interactive and interesting teaching tools for the classroom, such as libraries of immersive information, experiences for certain subjects, or learning goals. In terms of students, VR can improve technical education, medical simulations, and STEM courses by enabling students to grasp abstract concepts and get practical experience in low-risk virtual environments. Fully immersive VR experiences have the added advantage of reducing distractions during remote learning, encouraging students to pay close attention in class. In addition, many VR affordances and features can support learning in a way that is not achievable in conventional classroom settings (Ferdinand et al., 2023). According to Won, Mocerino, Tang, Treagust, and Tasker (2019), VR offers a distinctive manner for teachers to impart knowledge and for students to interact with course materials. Ogbonna (2022) asserts that in virtual reality, users can interact with made-up or fabricated objects as well as engage with and control replicated actual elements in the environment. Because of this, VR enables students to act and see the outcomes of their actions without facing consequences, as is the case in real-world scenarios. As a result, risky and unusual events can be reproduced in VR, allowing students to learn without risk. Practicing surgical procedures or learning safe machine tool use are a couple of examples (Boyle, 2017). Additionally, students can learn about the potentially catastrophic repercussions of failure from not adhering to procedures or exceeding design requirements in a controlled setting without risking equipment damage or human life (Potkonjak et al., 2016). The study also asserts that VR enables the visualisation of ideas that are abstract or challenging to connect to practical experiences, such as an augmented reality application that uses markers to instruct students about electromagnetism and the interactions between various circuit components (Boyle, 2017). In contrast to the traditional learning method, which is typically language-based, conceptual, and abstract, a VR learning environment supports active learning and aids students in understanding abstract knowledge, as was previously noted by Ray and Deb (2016). Furthermore, virtual reality can help students learn abstract concepts because they can experience and visualize these concepts in the virtual environment. One of the most significant strengths of VR is that it changes the role of the teacher from the deliverer of knowledge into a facilitator who helps the students explore and learn and thus strongly empower and engage students as they have control over the learning process.

The Teaching of History Using Virtual Reality

Our argument suggests that with the current advancement in technology in the developing countries, new forms of teaching history must appear. VR using mobile applications is one of these new forms since smartphones and computer tablets are becoming a part of the student's daily culture (Hussein, 2015). The use of VR has long been a question of great interest in a wide range of fields in education. Studies reports that early uses of virtual reality were in hard science education and focused on visualizing chemical reactions or learning about molecules by assembling them in a virtual environment (Boyle, 2017; Häfner, et al, 2013). For instance, a study by Hussein (2015) proves how virtual reality (VR) technology is used in surgical education and how this might help surgeons in figuring out their degree of ability prior to doing surgery on a patient. Due to these advantages, medical education has proven a strong interest in VR, particularly in the field of human anatomy. A university in Brazil modelled a complete charcoal mini-blast furnace with all its sub-subsystems, according to a report by Boyle (2017), and its application included more information, videos, and 360-degree photos from real blast furnaces. This was done to teach engineering students how the process works and how the various subsystems interact. The use of VR in education has been concentrated in the in medicine, automotive, and aerospace industries curricula (Häfner, et al, 2013), overlooking the history curriculum. However, a major problem with this kind of application of VR in education is that it is monolithic in nature and tends to exclude other subjects in the curriculum. Some evidence suggests that VR is difficult to apply in social sciences, although further use it is needed to confirm this finding. For instance, the review by Hamilton et al. (2021), which focused

on evaluating the general effectiveness of VR in education, found that the arts, humanities, and social sciences were underrepresented and concluded that a key factor in this under-representation may be the dearth of VR learning content, experiences, and teaching tools. The study encourages educational professionals to address the three concerns found by Hamilton et al. (2021) to lay the groundwork for the use of VR in the teaching of history. The use of technology is one area where things are becoming better, thus it is up to the teachers to integrate this technology into their history lessons.

Areas Where VR Is Useful in the Teaching of History

The study considered some areas that VR can be useful as a tool in digital education considering that there is a growing body of literature that recognizes the importance of it (Bogiannidi et al, 2023; Joosub, 2023; Ogbonna, 2022). Thus, studies have documented the use of VR in medical and engineering education and hence what researchers know about it is based on case studies undertaken in hard sciences. Besides its use in hard sciences, Boyles (2017) argues that VR is also applied in the learning of foreign language through allowing students to have interactions with native speakers using 3D virtual worlds using Desktop. One such programme is known as Second Life since it is open-ended and enables for user-to-user communication via voice and text. It is also free to access. A much-debated question therefore is why VR is not reported to be used in the teaching of history curriculum. For that reason, the argument of the current study confirms that one of the greatest uses for virtual reality in the realm of history is to take virtual field trips to historical sites or see historical events first-hand (Choi, 2016). As backed by Hu-Au and Lee (2017) who argue that Increased student engagement, active, constructivist learning, more frequent authentic learning experiences, sympathetic encounters, the chance for students to use their creativity, and a space to concretely visualise abstract ideas are all benefits of virtual reality. This is exactly what the Google Expeditions Pioneer Programme carries out, allowing students to travel to and explore a virtual location using Google Cardboard and their smartphones. The teacher acts as the tour guide for the field trip, and their app has the capability to highlight spots on their students' perspectives to help focus their attention and offers more information to explain specific sights in more depth (Ray and Deb, 2016). For students participating in live field tours to historical locations, augmented reality travel guides are available for mobile devices to enhance their learning and let them explore independently (Boyles, 2017).According to the study, a range of abilities with various labels are on the rise in the 21st century, including creativity, curiosity, critical thinking, and global competency (Zhao et al., 2021). The Kai XR app, a subscription-based immersive learning platform created to solve educational opportunity gaps like access to field excursions and other off-site enrichment activities, is a great tool that history teachers can employ. Consequently, the platform supplies narrated, multilingual virtual field visits to monuments, historical sites, museums, and even outer space. A more current software called the Kinfolk was also created and released. With the help of this app, students may interact with historical figures who were Black leaders in real life. They can view each leader and access information about them, including biographies and playlists. Therefore, the study argues that VR can be applied to social science in general and history curricula in particular, expanding its usefulness beyond engineering and medical education. Our arguments are ground-breaking because they highlight the overall significance of VR in the education sector, where its use and application are still in their infancy. This study sheds light on this uncharted territory by analysing the real-world implications of it in the curriculum for teaching history.

Conclusion and Implications

The analysis in this paper revealed significance differences in the use of VR in hard sciences and social sciences such as the history curriculum. This study highlighted how the 4IR and its digital tools and technologies in combination with reliable connectivity can provide entirely new platforms for the teaching of history that are designed to provide access to quality educational resources, support remote learning and enhance the overall educational experience for learners, especially in some of Africa's most

rural and under resourced communities. While the 4IR and the digitalization of education has not transformed the social dynamics associated with it, evidence in this study shows that the digital transformations have generated educational innovations that have the potential to increase cognitive and analytical skills as well as creativity and autonomous learning as dictated by the 21st century. The study advances the argument that digital education offered via mobile devices can effectively leapfrog the traditional and prevailing teaching and learning methods that are already outdated. While there is a recognition that VR has a vital role in the teaching of history as a subject for a technology-rich world, fluency with it, at times, teachers' choice to use it as an education tool in inappropriate ways often become obstacles to harnessing its full potential. This is since some educators in developing nations are having difficulty coping with the sheer volume of modern technology and figuring out how to integrate them in open-concept classrooms both securely and effectively. As a result, even though the usage of VR can improve classroom experiences and extend opportunities at all levels of learning, many African countries are suffering from a dearth of trained and certified teachers who can employ it in the classroom. The research concludes that while there is ongoing digitalization of education and usage of VR in teaching history, there is no evidence of quality gains and a broadening of its application. Considering the arguments presented in this paper, the study recommends that schools in developing countries must train their in-service teachers so that they are able to ease learning across many modalities: face-to-face (in the classroom) and virtual (online); synchronous and asynchronous; analogue and digital. In-service teachers therefore need support from the future fit leaders who understand the new education landscape created by the 4IR. In this regard, history teachers must master the full range of available digital tools for teaching and learning. As such, they must be capable to move learning material online and customise it to the demands of the 4 IR. Consequently, teachers are implored to embrace a digital mindset so that they are constantly upgrading their skills to deliver teaching with modern technologies. As for those institutions training teachers, the teacher education programme must be reimagined and reframed to incorporate curriculum components that demands that products of their institutions are able to use digital technologies and tools such as VR in the teaching and learning process. Further, the work presented here showed that VR is indeed capable of changing the teaching of history curriculum. However, due to the limited knowledge on the teaching of social sciences using VR, our arguments should be read with caution and call for further investigation into the affordances of it in the teaching of history curriculum to confirm and or refute the submissions made here. As such, this is foundational work for future efforts to assess the use of VR in teaching the social science education.

References

Bogiannidis, N., Southcott, N. J., & Gindidis, M. (2023). An exploration of the possible educational opportunities and the challenges at the intersection of the physical and digital worlds occupied by 10–14 year-old students. *Smart Learning Environments, 10*(26), 1-21. https://doi.org/10.1186/s40561-023-00246-w.

Boyles, B. (2017). Virtual Reality and Augmented Reality in Education. Master thesis. Center for Teaching Excellence, United States Military Academy: West Point, NY.

Brown-Martin, G. (2017). Education and the fourth industrial revolution. Available at: https://www.groupemediatfo.org/wp-content/uploads/2017/12/FINAL-Education-and the-Fourth-Industrial-Revolution-1-1-1.pdf. Accessed on 19 June 2020.

Choi, D. H. (2016). (Ed). *Emerging tools and applications of virtual reality in education*. IGI Global.

Chomunorwa, S., Mashonganyika, E. S., Marevesa, A. (2023). Digital transformation and post-Covid-19 education in South Africa: a review of literature. *South African Computer Journal 35*(1), 91–100. https://doi.org/10.18489/sacj.v35i1.1101.

Dick, E. (2021). *The promise of immersive learning*. Information Technology & Innovation Foundation, Washington, DC.

Ferdinand, J., Soller, S., Hahn, J. U., Parong, J., & Göllner, R. (2023). Enhancing the effectiveness of virtual reality in science education through an experimental intervention involving students' perceived usefulness of virtual reality. *Technology, Mind, and Behavior*, 1-15 https://doi.org/10.1037/tmb0000084.

Fernandez, M. (2017). Augmented virtual reality: How to improve education systems. *Higher Learning Research Communications, 7*(1), 1–15. https://doi.org/10.18870/hlrc.v7i1.373.

Häfner, P., Häfner, V., & Ovtcharova, J. (2013). Teaching methodology for virtual reality practical course in engineering education. *Procedia Computer Science* (25), 251 – 260.

Haleem, A., Javaid, M., Qadri, M. A., Suman, R. (2022). Sustainable operations and computers. 275–285.

Hamilton, D., McKechnie, J., Edgerton, E., & Wilson, C. (2021). Immersive virtual reality as a pedagogical tool in education: a systematic literature review of quantitative learning outcomes and experimental design. *Journal of Computers in Education, 8*(1), 1–32.

Hu-Au, E. and Lee, J. J. (2017). Virtual reality in education: a tool for learning in the experience age. Int. J. Innovation in Education, 4(4), 215–226.

Joosub, S. (2023). *How digital technologies can transform education in sub-Saharan Africa*. Connected Education, Vodafone: South Africa.

Langthaler, M., & Bazafkan, H. (2020). Digitalization, education and skills development in the Global South: An assessment of the debate with a focus on Sub-Saharan Africa. Vienna: Austrian Foundation for Development Research. https://www.oefse.at/fileadmin/content/Downloads/Publikationen/Briefingpaper/BP28Digitalization.pdf.

Potkonjak, Veljko, et al. (2016). Virtual laboratories for education in science, technology, and engineering: A review. *Computers & Education 95*, 309-327.

Ray, A. B., & Deb, S. (2016). Smartphone based virtual reality systems in classroom teaching: A study on the effects of learning outcome. In 2016 IEEE Eighth International Conference on Technology for Education (T4E), pp. 68–71.

Stutchbury, K., Ebubedike, M., Amos, S., & Chamberlain, L. (2023). Professional development in the digital age: supporting improvements in teacher education through MOOCs, Open Learning: *The Journal of Open, Distance and e-Learning*, https://doi.org/10.1080/02680513.2023.2195875

Won, M., Mocerino, M., Tang, K. S., Treagust, D. F., & Tasker, R. (2019). Interactive immersive virtual reality to enhance students' visualisation of complex molecules. In M. Schultz, S. Schmid, & G. Lawrie (Eds.), Research and practice in chemistry education, pp. 51–64. Springer. https://doi.org/10.1007/978-981-13-6998-8_4.

Yende, S. J. (2021). A Transition towards the fourth industrial revolution (4IR) in the South African education sector: A perspective from rural-based higher education. African Journal of Development Studies, 11(2), 55-75. DOI:https://doi.org/10.31920/26343649/2021/v11n2a3.

Yusuf, B., & Walters, L.M. (2020). Restructuring educational institutions for growth in the fourth industrial revolution (4IR): A systematic review. *iJET (15)*3, 93-109.

Zhao, Y., Llorente, A. M. P., & Gómez, M. C. S. (2021). Digital competence in higher education research: A systematic literature review. Computers & Education, (168), https://doi.org/10.1016/J.COMPEDU.2021.104212.