



Chapter 6

Use of Current Cutting-Edge Technologies in South African Physical Sciences Classrooms

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Abstract

Technology is a dynamic tool that has revolutionised numerous vocational industries, particularly education. As an undergraduate student at the University of Johannesburg with majors in physical sciences and life sciences, it is troublesome and fascinating to observe and witness the potential and problems that arise due to the adoption of different technologies for physical sciences teaching and learning in South African classrooms. Tools such as virtual reality (VR), augmented reality (AR), and AI can help students visualise complex scientific phenomena that might be difficult to grasp through traditional methods. However, the integration of these technologies presents significant challenges, especially in the context of South Africa, where there are disparities in access to resources, limited funding, and gaps in teacher training. This duality of immense potential constrained by practical challenges highlights both the promise and the complexity of effectively integrating technology into education.

The primary aim of my interest in the use of technologies in physical sciences classrooms is to study and report on the effectiveness of various innovative technological tools that



physical science teachers can use to teach abstract physical sciences concepts, enhance learners' learning experience, motivation, and promote the development of the four Cs of the Fourth Industrial Revolution – critical thinking, communication, collaboration and creativity. Despite the ongoing advocacy of the use of technology and innovative pedagogies, science teachers across the country are still using traditional, teacher-dominated approaches that are not effective in helping learners acquire full conceptual understanding and necessary skills for the 21st-century era and beyond. Even those who have access to different technologies for teaching and learning are not using them effectively because of numerous challenges, such as large class sizes, a lack of adequate knowledge and skills, and a lack of confidence. Currently, technologies such as artificial intelligence (AI), VR, and AR are being introduced as cutting-edge, innovative and effective technologies that South African physical science teachers can use to enhance learners' conceptual understanding, motivate learners towards learning science, make learning fun and interesting, and equip learners with relevant 21st-century skills.

Accordingly, the focus of this study is to explore the integration of cutting-edge technologies such as VR, AR, and AI in South African physical sciences classrooms, with a particular focus on their adoption, effective utilisation, and impact on learners' learning outcomes. A mixed-method approach was employed in this study using face-to-face interviews with semi-structured questions to assess physical science teachers' perceptions and experiences and through classroom observations of how they implement these technologies. The findings reveal a growing interest in the use of technologies such as VR, AR, and AI for the teaching and learning of physical sciences; however, there are numerous challenges that hinder the effective and optimal utilisation of such tools. Challenges such as inadequate resources and a lack of teacher training have a negative impact on the effective implementation of VR, AR, and AI for teaching and learning of physical sciences in South African classrooms. Therefore, this study concludes with recommendations for policymakers, teacher-educators, higher education institutions, and technology companies and providers to collaborate and

work together to overcome these challenges and help teachers optimally use these cutting-edge technologies in South African physical sciences classrooms.

Introduction

Incorporating advanced technologies in education has become very important, as it prepares learners in schools for this fast-changing world, which has many ICT resources (Dimitriadou, 2023). In South Africa, where physical sciences are challenging due to abstract concepts, technologies such as VR, AR, and AI provide creative solutions to overcome these conceptual challenges. While there is support for using technology in education, South African physical sciences classrooms face challenges in integrating these tools because of a lack of resources, inadequate teacher training, and the continued use of traditional teaching approaches. This research aims to assess how well VR, AR, and AI can be integrated into physical sciences classrooms in South Africa; it also aims to examine the obstacles to adoption and potential outcomes. It explores educators' encounters, obstacles to utilising technology, and how these resources can improve students' learning experiences through endorsing critical thinking, communication, collaboration, and creativity (the four Cs of the Fourth Industrial Revolution).

Literature Review

I will summarise how technology is used in education, with a particular emphasis on the emerging tools of VR, AR, and AI in the sciences. Most of the time, individuals wonder what VR and AR are and how they were introduced to the world. There is a need to shift the way teaching and learning occur because traditional methods are becoming less useful, especially in STEM fields such as physical sciences. Hands-on, interactive methods are necessary to involve students in the current digital era. This factor was also a consequence of the impact of the COVID-19 pandemic worldwide. The pandemic sped up the adoption of online and digital educational resources. Educational institutions around the world had to adjust to online learning platforms (Guzzo, 2023).

The difference between these ICT tools is that VR is an immersive experience in which learners use devices such as headsets to explore a fully simulated environment, whereas AR is a technology that overlays digital content in the real world, often through apps on smartphones or tablets. Research has indicated that VR can be effective in science education by creating immersive learning environments that enhance learners' understanding of complex scientific concepts. AR allows digital content to be placed over the real world, assisting in comprehending spatial and abstract ideas within physical sciences, such as forces and motion.

Obstacles to incorporating technology in South African classrooms: Recent research has identified difficulties in implementing technology, including limited resources and inadequate teacher training (Letseka, 2022). Additionally, systemic problems such as unequal funding and lack of infrastructure add to the delayed adoption of these technologies. The focus on the 4Cs, which includes critical thinking, communication, collaboration, and creativity, in education corresponds with the objectives of the 4IR. The literature emphasises how crucial these skills are in preparing learners for future jobs and ensuring that they can succeed in a world dominated by technology (Mohapi, 2024). These are the skills that are acquired by all the learners, which may have started at the very wrong time, but the technological tools make learners interested while also contributing to the skills required.

Research Methodology

This research utilises a combination of qualitative and quantitative data in a mixed-method approach to provide a thorough analysis. Face-to-face interviews with semi-structured questions were conducted with physical sciences educators from different schools in Gauteng (Soweto) and KwaZulu Natal (Zululand) in South Africa to gain insight into their views and interactions with VR, AR, and AI technologies.

Additionally, classroom observations were carried out to assess real-time technology use and identify areas of improvement. However, during this research, it was noted that

most of the teachers never used these tools (AR and VR) in the classroom because of the lack of funding from the Department of Education. In Gauteng, only six teachers in Gauteng experienced VR in the classroom with their learners. One of the things that has been highlighted is that the learners have been introduced to the use of AI tools such as ChatGPT and Meta AI. The teachers indicated that these tools technological tools help the learners breakdown the questions.

Sample: The sample consisted of 20 physical sciences teachers from diverse socio-economic backgrounds, ensuring a range of perspectives.

Data Collection: Data were collected through face-to-face interviews with semi-structured questions, which focused on teachers' attitudes toward technology use, perceived benefits, and challenges. Classroom observations documented actual instances of technology use, where feasible, and recorded both teacher and student engagement.

Data Analysis: Qualitative data were analysed thematically to identify recurring themes. Quantitative data from a Likert-scale survey on teachers' familiarity with and comfort with VR, AR, and AI were statistically analysed.

Results

The findings of this research reveal potential benefits as well as obstacles for incorporating advanced technologies such as VR, AR, and AI in physical sciences classrooms in South Africa.

Educators' restricted exposure to VR and AR technologies: A notable discovery was that most teachers (14 out of 20) had not utilised VR or AR in their classrooms, mainly because of financial constraints. Only six teachers in Gauteng have access to VR, enabling them to showcase intricate physical science concepts using immersive environments. Most teachers are unable to utilise VR and AR tools for enhanced conceptual understanding because of their limited availability.

Integration of artificial intelligence technology in educational settings: Numerous educators are now incorporating AI tools such

as ChatGPT and Meta AI to assist students in dissecting questions and comprehending complicated subjects. Approximately 75% of the teachers believed that AI was beneficial for this purpose. Nevertheless, they also highlighted the potential for misuse, as students could become overly dependent on AI without actively practicing critical thinking.

Inequality in availability due to geographic location and economic position: The results revealed a disparity in digital access, as the urban schools in Gauteng had more resources than did the rural schools in KwaZulu Natal. Educators in remote locations stated that the lack of essential digital resources worsened the current disparities.

High levels of optimism are observed; however, there is a lack of action taken. Even with limited access, most teachers had a favourable outlook on the use of VR, AR, and AI, acknowledging their ability to improve student motivation and comprehension. Nevertheless, the lack of adequate resources continues to make implementation difficult.

Discussion

The results of this research show that teachers are increasingly interested in incorporating VR, AR, and AI into the physical sciences curriculum, but they face significant challenges in their successful implementation. Most teachers are restricted in their access to these tools due to insufficient funding from the Department of Education, causing notable differences in technological integration based on socio-economic status, especially the teachers in the province of KwaZulu Natal in Zululand, who have not received any training about the use of these tools since the schools do not have such tools due to inequalities in the distribution of resources. Educators who were able to use VR saw its beneficial effects on the learners' grasp of abstract ideas, but only a few learners were able to take advantage of these resources. One of the challenges is that these tools are very expensive.

Teachers' readiness to integrate easily accessible technologies such as ChatGPT into their teaching shows the

increasing use of AI tools in classrooms. Nonetheless, using AI too much may lead to worries about the lack of critical thinking, as students might start relying on answers generated by AI without truly participating in solving problems (Al Darayseh, 2023). This highlights the importance of providing training to both educators and learners on the proper utilisation of AI within educational environments. On the basis of these results, advanced technologies have the potential to revolutionise physical sciences education, but it is crucial to address funding, resource allocation, and teacher training issues to ensure fair access and optimal utilisation.

Recommendations

The Department of Education should prioritise funding for VR and AR tools, especially in underserved regions, to bridge the technology gap. Partnerships with technology providers could provide affordable options for schools lacking these resources. Comprehensive training programmes should be introduced to equip teachers with practical knowledge and skills to integrate VR, AR, and AI into their curriculum effectively. Such programmes need to concentrate on developing technical skills as well as pedagogical strategies for utilising these tools. With the growing reliance on AI tools in educational settings, establishing guidelines that encourage the responsible and efficient utilisation of AI is crucial. The guidelines should highlight the significance of critical thinking and advise against relying too much on AI to answer questions. Through partnerships with tech firms, the educational field can potentially obtain improved availability of VR, AR, and AI resources, potentially receiving reduced rates or contributions for disadvantaged schools.

Conclusion

This research emphasises the opportunities and difficulties of implementing advanced technologies in South African physical sciences classrooms. Although VR, AR, and AI can enhance learning experiences and boost student engagement, their successful implementation is hindered by disparities in resource allocation

and inadequate teacher preparation. Resolving these problems necessitates a united effort from the Department of Education, educational institutions, and technology providers to guarantee that all students can access innovative educational resources equally. When these technologies are incorporated efficiently, they can greatly improve student academic achievement, drive, and the acquisition of skills needed for success in the 21st century.

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