

Research Article

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Exploring AI for Improving SDG4 in South Africa: The Phenomenological Approach

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Abstract

Background/purpose. This paper explores Artificial Intelligence (AI) in advancing Sustainable Development Goal 4 (SDG4) in South Africa. Although there has been a drastic interest in AI's transformative capacity in education, limited studies address its pitfalls and benefits using a phenomenological approach focusing on the South African context.

Materials/methods. By adopting a phenomenological lens, this study delves into the lived experiences of six high school teachers grounded in the contextual realities of AI in South Africa using a purposive sampling technique. We used a semi-structured interview guide to conduct an in-depth thirteen-minute interview and analysed the data thematically.

Results. The study generated two themes through qualitative analysis, including unequal resource distribution and enhanced quality education. The study proposed AI-driven solutions tailored to the contextual nuances of South Africa. By incorporating diverse perspectives and utilising AI technologies, an approach aims to enhance educational outcomes, promote inclusivity, and bridge existing education access and quality gaps.

Conclusion. This research contributes to the growing discourse on AI's potential to address complex societal challenges. It offers insights for policymakers, educators, and technologists seeking to leverage AI for sustainable development initiatives in South Africa and beyond.

1. Introduction

In 2015, the United Nations Member States adopted the 2030 Agenda for Sustainable Development, establishing 17 Sustainable Development Goals (SDGs) as a universal call to action to end poverty, protect the planet, and ensure prosperity for all by 2030 (Carlsen & Bruggemann, 2022). These goals address urgent global challenges such as poverty, inequality, climate change, and education, emphasising the interconnectedness of social, economic, and environmental dimensions. Central to this agenda is SDG4, which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. It includes ten targets addressing universal primary and secondary education, access to affordable technical and vocational training, elimination of gender disparities, and improved educational infrastructure.

In South Africa, achieving SDG4 is especially critical due to the legacy of apartheid, which created deep-rooted disparities in educational access and quality (O. Opesemowo, 2024). Ongoing issues such as unequal resource distribution, a shortage of qualified teachers, and socio-economic inequality continue to hinder progress. However, integrating Artificial Intelligence (AI) into the education system presents a promising opportunity to bridge these gaps. AI can personalise learning by adapting content to individual student needs, offering targeted support to disadvantaged learners. It can also automate routine administrative tasks, freeing teachers to focus on instruction and mentorship.

Furthermore, AI-powered analytics can identify learning trends, track student progress in real-time, and support data-informed resource allocation. These technologies promote inclusion by providing adaptive tools for learners with disabilities and language barriers. When responsibly implemented, AI can act as a strategic enabler of equity and quality, supporting South Africa's efforts to realise SDG4 (Madalinska-Michalak et al., 2022). Despite significant strides since apartheid officially ended on 4th May 1990 by the National Party led by Daniel F. Malan, educational disparities remain. For 42 years, apartheid policies institutionalised racial segregation, providing non-white students with inferior resources and limited opportunities. Addressing this history requires sustained efforts and inclusive policies prioritising equitable education access. As demonstrated in other advanced countries, AI can support South Africa's educational transformation. Baena-Morales et al. (2024) note that South Africa's education system is characterised by disparities in access, quality, and inclusivity. Similarly, Vist and Holdhus (2023) highlight persistent barriers such as socio-economic inequality, inadequate infrastructure, and insufficient teacher capacity, all of which impede progress toward SDG4.

In this context, AI emerges as a transformative tool capable of supporting educational interventions, addressing systemic challenges, and enhancing equitable access to quality education. This study adopts a phenomenological approach to highlight the subjective experiences of stakeholders, including students, educators, policymakers, and community members. It aims to uncover nuanced challenges and aspirations within South Africa's education system and identify key areas where AI can drive meaningful change. This investigation is grounded in the practical realities of the South African educational landscape. The study seeks to develop AI-driven solutions that are contextually relevant, culturally sensitive, and responsive to stakeholders' diverse needs by bridging the gap between theory and practice. Leveraging advanced AI technologies such as machine learning, natural language processing, and computer vision, the research proposes innovative interventions that promote inclusivity, equity, and excellence in education (Baena-Morales et al., 2024). At its core, the study is motivated by a commitment to using technology for social good and contributing to the global sustainable development agenda. Dabengwa (2024) emphasises that showcasing AI's transformative potential in education can inspire collaborative efforts among policymakers, educators, technologists, and communities to drive positive change in South Africa and beyond. Through collective action and innovation, the vision of making quality education a fundamental right

and a tangible reality can be achieved. Recent studies (Abulibdeh et al., 2024; Nasir et al., 2023; Opesemowo & Adekomaya, 2024; Saini et al., 2023) have examined AI's role in advancing SDG4 using diverse research approaches. However, there is still a notable gap in exploring this topic through the lived experiences of South African participants. Incorporating firsthand perspectives provides deeper insights into local barriers and priorities, enabling the development of targeted, effective, and sustainable interventions. By integrating real-life experiences into AI-based educational strategies, this bottom-up approach ensures that solutions are innovative and aligned with the actual needs of communities. In doing so, AI becomes a powerful tool for enhancing education and lifelong learning opportunities across South Africa.

1.1 Rationale for the Study

The rationale for exploring AI in advancing SDG4 in South Africa is grounded in its potential to address persistent educational challenges, capture local contextual realities, uncover feasible pathways for AI integration, promote inclusivity, and support sustainable development. This study seeks to generate context-specific and targeted AI-based solutions to enhance the quality and accessibility of education in South Africa. Despite ongoing reform efforts, the country grapples with deep-rooted disparities in access to quality education and educational outcomes issues that continue to slow progress toward achieving SDG4.

AI presents an innovative avenue for improving educational delivery by leveraging emerging technologies to design more responsive and effective interventions. To ensure these solutions are meaningful and relevant, the qualitative study adopts an experience-based approach that centers on the voice of those embedded within the South African education system. The study captures nuanced insights often overlooked in top-down technological implementations by focusing on the lived experiences of key stakeholders such as educators, learners, and policymakers. These insights inform the identification of practical applications for AI tools, including machine learning, natural language processing, and computer vision, ultimately supporting the development of culturally and contextually appropriate educational innovations.

The study emphasises the importance of SDG4, an inclusive and equitable quality education for all. However, achieving this goal requires addressing existing disparities and barriers to access. AI has the potential to enhance inclusivity by providing a personalised learning experience, overcoming language barriers, and expanding access to educational resources. By exploring AI within a phenomenological framework, this research aims to identify ways AI can be leveraged to promote educational inclusivity and equity in South Africa. The exploration of AI for improving SDG4 aligns with broader sustainable development objectives.

1.2. Research Statement

This study investigates how AI can be leveraged to improve educational quality, accessibility, and equity in South Africa in alignment with SDG4. Using a phenomenological approach, the research explores the lived experiences of educators in adopting AI-driven educational technologies. The study aims to identify key enablers, barriers, and ethical implications of AI in education, providing insights into how AI can enhance inclusive and lifelong learning within the South African context. This study explores AI's role in improving the quality, accessibility, and inclusivity of education in South Africa in alignment with SDG4. Using a phenomenological approach, the study seeks to understand the lived experiences of educators, students, and policymakers in adopting AI-driven educational technologies. The research aims to provide insights into how AI can support equitable and lifelong learning in the South African education system by identifying opportunities, challenges, and ethical considerations.

2. Literature Review

AI is increasingly being used as a tool to support SDG4, which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (United Nations, 2015). Integrating AI in education has significantly transformed teaching methodologies, student engagement, and learning outcomes (Chetry, 2024; Yadav, 2024). However, the successful adoption of AI-driven tools in classrooms depends largely on teachers' experiences, readiness, and attitudes toward these technologies (Ružičić et al., 2024; Sibug et al., 2024). In South Africa, AI-driven tools are being explored to address challenges such as teacher shortages, learning disparities, and curriculum delivery inefficiencies (UNESCO, 2021). AI adapts content delivery based on individual student performance, offering customised feedback and adaptive assessments (Yuldashev et al., May, 2024). AI-powered tutors assist learners by providing real-time guidance and feedback, reducing the burden on teachers (Opesemowo & Adewuyi, 2024; Zhang & Leong, 2024). AI enables faster assessment of students' work, helping teachers focus on pedagogical strategies rather than administrative tasks (Damaševičius, 2024; Joel et al., 2025). AI chatbots have emerged as transformative tools in education, providing learners with immediate support through answering questions, explaining concepts, and guiding them through coursework (Labadze et al., 2023). Their integration into educational settings enhances personalised learning experiences and fosters student engagement, making them valuable assets for both students and educators.

Despite these advantages, studies have found that South African teachers face significant barriers to AI adoption, including limited digital infrastructure, lack of AI literacy, concerns over data privacy, and resistance to pedagogical changes (Achruh et al., 2024; Agarwal & Vij, 2024). A phenomenological research approach can help capture teachers' lived experiences engaging with AI, shedding light on their concerns, successes, and challenges in AI implementation (Creswell & Creswell, 2017). SDG4 is one of the 17 global goals adopted by the United Nations in 2015 as part of the 2030 Agenda for Sustainable Development. It aims to “ensure inclusive and equitable quality education and promote lifelong learning opportunities for all” (United Nations, 2015). AI has emerged as a critical enabler in achieving SDG4 by enhancing access to education, personalising learning experiences, and improving efficiency in teaching methodologies (UNESCO, 2019). Research highlights AI's role in reducing learning gaps by identifying struggling students and offering tailored interventions (Essien et al., 2021). Karimov et al. (2024) reveal that supporting teachers with AI-driven analytics provides insights into student performance, engagement levels, and learning progressions while expanding education access through AI-powered distance learning solutions, particularly in rural and underprivileged communities. In South Africa, AI can help bridge educational inequalities stemming from socioeconomic disparities, geographic isolation, and inconsistent teaching quality (Basharat, 2024). However, alongside its benefits, AI in education raises profound ethical concerns that demand critical attention. One major issue is algorithmic bias, where AI systems—trained on datasets that reflect historical and systemic inequities—may perpetuate or even amplify discrimination against marginalised groups. For example, algorithms may fail to account for linguistic diversity, cultural variations, or socio-economic contexts specific to South Africa, thereby disadvantaging learners from underrepresented backgrounds (Magangane et al., 2024). Additionally, algorithmic opacity is the inability to fully understand or explain how AI systems arrive at certain decisions, complicating accountability and trust in AI tools used in educational assessment and placement (Geethanjali & Umashankar, 2025).

Data privacy and surveillance concerns further complicate AI integration, particularly when educational data are collected without informed consent or used beyond their original scope. Students and teachers may be unknowingly subjected to constant monitoring through learning analytics, raising questions about autonomy and digital rights. Moreover, the lack of culturally

relevant AI content risks reinforcing a one-size-fits-all model of education that fails to reflect local values, languages, and learning needs—undermining the inclusive spirit of SDG4.

The study employs a phenomenological approach to address these challenges, focusing on the lived experiences of teachers engaging with AI. This method captures contextual nuances and highlights opportunities and obstacles in AI integration. The researcher acknowledges the subjective nature of qualitative analysis but views it as a strength that offers more profound insight into the real-world implications of AI in education. Ensuring that AI aligns with SDG4's inclusive goals requires critical attention to ethical issues, equitable design, and culturally sensitive implementation to promote truly transformative and just educational practices in South Africa.

2.1. Theoretical Frameworks

The literature on AI in education encompasses various theoretical frameworks that underpin the integration of AI technologies to enhance educational outcomes. The application of AI in education finds firm footing in various psychological theories that emphasise how students learn, what motivates them, and how they regulate their learning processes. AI systems, especially those that personalise instruction, provide feedback and support autonomous learning, which aligns with and enhances several psychological theories (including Bandura's Social Cognitive Theory, Bloom's Mastery Learning Theory, Constructivist Cognitive Theories, Cognitive Load Theory, and Self-Determination Theory) that underpin effective teaching and learning. However, this study focused on the constructivist cognitive theory.

Constructivist cognitive theories developed by Jean Piaget and Jerome Bruner emphasise that learners actively construct knowledge via interaction with their environment and prior experience. Piaget (1952) proposed that cognitive development occurs in stages including sensorimotor, preoperational, concrete operational, and formal operational, each reflecting increasingly complex forms of thinking. He argues that learning takes place through assimilation and accommodation, where learners integrate new information into existing schemas or modify those schemas to incorporate new experiences. This theory promotes active engagement, discovery, and problem-solving as essential to meaningful learning.

Subsequently, Bruner (1966) expanded Piaget's ideas by highlighting the role of social and cultural contexts in learning. He introduced the concept of "scaffolding", where learners receive temporary support from teachers or peers until they can perform tasks independently. Bruner also identified three modes of representation: enactive, iconic, and symbolic, which inform how knowledge is processed and internalised. These theories have shaped modern educational practices, encouraging learner-centered and inquiry-based approaches. Technologies like AI support constructivist principles by personalising instruction, offering real-time feedback, and enabling interactive exploration (Fosnot, 2013). When used effectively, AI can facilitate deeper conceptual understanding and promote autonomy in learners. Thus, integrating AI into educational systems is a structural enhancement of constructivist learning environments, aligning technological tools with cognitive development processes to foster more responsive and equitable education (Grubaugh et al., 2023).

2.2. AI Applications in Education

The literature on AI in education highlights its transformative potential in addressing educational challenges and enhancing learning outcomes. Intelligent tutoring systems, adaptive learning platforms, and educational data mining techniques have become practical tools for personalising instruction, providing immediate feedback, and promoting student engagement (Szalkowski & Johansen, 2024). Studies have demonstrated the efficacy of AI-driven interventions in improving academic performance and narrowing achievement gaps across diverse student populations (Fitria,

2021; O. A. Opesemowo, 2024; Rivombo, 2018; Sulaiman et al., 2022; Tahiru, 2021; Zhang & Aslan, 2021). Sari et al. (2024) stated that AI-driven tools have shown significant potential in addressing educational challenges related to access, equity, and quality by providing students with scalable and personalised learning experiences. These tools leverage adaptive learning systems, intelligent tutoring, and data analytics to tailor educational content to individual needs, enhancing engagement and outcomes. Moreover, natural language processing and machine learning algorithms can facilitate language translation and comprehension, overcoming linguistic barriers to education in multilingual contexts like South Africa. Therefore, integrating AI into South Africa's educational framework holds substantial promise for advancing SDG4 by fostering inclusive, equitable, and quality education tailored to the country's unique linguistic, cultural, and socio-economic realities.

2.3. Integrating AI for SDG4 in South Africa

While the potential of AI to advance SDG4 in South Africa is increasingly recognised, there is a paucity of research specifically addressing the intersection of AI, phenomenology, and sustainable development in the country's educational context. This study seeks to fill this gap by employing a phenomenological approach to explore how AI can be harnessed to improve educational access, equity, and quality in South Africa, ultimately contributing to realising SDG4 objectives. Education is pivotal in achieving SDGs, particularly SDG4, which emphasises inclusive and quality education for all (Opesemowo & Adekomaya, 2024; Opesemowo & Ndlovu, 2024). The research underscores the importance of education in fostering environmental awareness, promoting sustainable lifestyles, and building capacity for socio-economic development (Ally & Wark, 2020; Lotriet & Twinomurinzi, 2021; Mbiza & Sinha, 2023; Uthmann, 2021). Educators can empower students to become active agents of change in their communities by integrating sustainability principles into curricula and pedagogical practices.



Figure 1. Sustainable Development Goals
(Source: <https://sdgs.un.org/goals>)

Fig. 1 illustrates the 17 UN SDGs, which form a global blueprint for achieving a better and more sustainable future by 2030. Arranged in a circular, colour-coded format, each segment represents a specific goal, from ending poverty and hunger to ensuring quality education, gender equality, clean energy, climate action, and strong institutions. The circle design emphasises the interconnectedness of these goals, highlighting that progress in one area supports advancement in others. At the center lies the SDGs emblem, symbolising a unified global commitment to peace, prosperity, and environmental protection for all.

3. Research Methodology

3.1. Design

This study adopted a phenomenological research design, specifically drawing on the Heideggerian (interpretive) tradition. As a qualitative methodology, phenomenology is concerned with understanding individual's lived experiences and how they make meaning of their world. Unlike the descriptive approach rooted in Husserlian philosophy, which seeks to bracket assumptions and describe experiences in their pure form, the Heideggerian interpretive phenomenology (also known as hermeneutic phenomenology) recognises that interpretation is embedded in human existence and that researchers cannot separate themselves from the interpretive process (Heidegger, 1962; van Manen, 2016). This approach is particularly valuable in educational research, where the goal is to understand how learners and educators experience and interpret educational phenomena such as teaching, learning, and classroom dynamics within specific socio-cultural and historical contexts (Bonyadi, 2023).

By embracing this interpretive lens, the study goes beyond surface-level descriptions to uncover the deeper meanings and existential structures that shape participants' experiences. As Creswell and Poth (2018) emphasise, phenomenology allows researchers to enter the lifeworld of participants, facilitating nuanced insights into how they engage with and make sense of their educational environment. The Heideggerian framework thus provides a robust foundation for exploring the complexity of human experience in education, acknowledging that meaning is always situated and mediated through language, context, and prior understanding.

Participants

Table 1. Study Participants' Profile

Participants	Teachers' subject	Experience
T1	Mathematics	15 years
T2	Life Sciences	10 years
T3	English Language	8 years
T4	Geography	6 years
T5	Technology	9 years
T6	Economics	11 years

The population for this study comprises all South African high school teachers, while the target population is restricted to one government-owned high school in South Africa. Six high school teachers (coded as T1-T6) were purposively selected based on their knowledge of AI and willingness to participate in the study (see Table 1). This purposive sampling method ensures that the sample represents a diverse group of high school teachers from diverse disciplines, experiences,

backgrounds, and commitment to SDG4. T1, a Mathematics teacher with 15 years of experience, integrates AI tools to personalise learning and mentor students from underserved communities. T2, teaching Life Sciences for 10 years, employs AI simulations to elucidate complex biological processes and promote environmental education. T3, an English Language teacher with 8 years of experience, utilises AI-driven language tools to enhance literacy and supports programs to improve language proficiency. T4, with 6 years of experience teaching Geography, incorporates AI-based mapping tools and engages students in climate change projects. T5, a Technology teacher with 9 years of experience, leads initiatives to integrate AI and robotics into the curriculum, striving to bridge the digital gap. T6, teaching Economics for 11 years, uses AI tools for economic modelling and educates students on policies promoting inclusive growth.

3.2. Data Collection and Analysis

The data collection process involves conducting semi-structured interviews with each participant. Experts scrutinised the interview questions to ensure alignment with the study objectives and eliminate ambiguity. The thirteen-minute interviews were designed to explore their experiences, perspectives, and challenges as high school teachers in South Africa. The data were collected from 15th September to 13th October 2024. The participants were asked open-ended questions about the problems and benefits AI poses to attaining SDG4. Each interview was recorded and transcribed for further analysis (Braun & Clarke, 2020; Fereday & Muir-Cochrane, 2006). The qualitative data was analysed using thematic analysis, identifying key themes and patterns. Through this qualitative analysis, the study hopes to delve deeper into the issues confronting high school teachers in South Africa and how to use AI to mitigate problems and improve SDG4 within the South African landscape. Member checking was also conducted to ensure data validity and analysed using a thematic approach to adequately capture the participants' perspectives.

3.3. Ethical Matters

The coding of participants as T1-T6 helped to maintain confidentiality and anonymity throughout the study, allowing teachers to share their insights and thoughts openly and honestly. This approach will ensure that the data collected is reliable and representative of the broader population of South African high school teachers. Before data collection, participants were assured of their right to opt-out whenever they felt unsafe. This ethical consideration was crucial in fostering trust between the researchers and participants, ultimately leading to more accurate and meaningful data. By prioritising the well-being and autonomy of the teachers, the researchers conducted a study that was respectful and considerate of the individuals involved. Overall, these ethical measures will contribute to the credibility and validity of the study's findings, enhancing its impact and relevance in education.

4. Findings

4.1. Theme 1: Unequal Resource Distribution

The participants were asked about the problems associated with AI implementations for SDG4. The theme was further divided into sub-themes, such as infrastructural and socio-economic disparities.

4.1.1. Infrastructural Disparity

Participants in T2 stated that *South Africa faces persistent challenges in its education system, including inequitable access, low academic achievement, and inadequate infrastructure. Progress has been slow despite efforts to address these issues, such as increasing funding and implementing education reform initiatives. The disparities in quality education between affluent and disadvantaged communities continue to widen, further perpetuating the cycle of poverty and inequality, T6 echoed.* The government must prioritise education as a fundamental right for all citizens and allocate

resources to ensure every child has equal opportunities to succeed. Investing in education is crucial for breaking the cycle of poverty and promoting social justice. By providing quality education to all children, regardless of their social status or background, we can create a more equitable society where everyone has the chance to thrive. We must work towards bridging the achievement gap and creating a level playing field for all students to reach their full potential. Only then can we truly address the systemic issues that have plagued our education system for far too long.

T4 revealed that schools in urban communities have adequate facilities because they can access government attention. However, it was further unveiled that *schools in rural areas often struggle with limited resources such as textbooks, computers, and adequate student seating.* This resource disparity can significantly impact the quality of education and opportunities available to students in these communities. Without proper funding and support, students in rural schools may fall behind their urban counterparts in academic achievement and future success. It is crucial that policymakers address this issue and allocate resources equitably to ensure that all students have access to a quality education, regardless of their geographical location.

4.1.2. Socio-Economic Disparity

Again, T3 noted the problems relating to the *disparities that persist along racial, socio-economic, and geographic lines.* These disparities often lead to a cycle of poverty and limited opportunities for students in rural areas, perpetuating the inequality that exists in our education system. By addressing these issues and providing adequate resources to schools in these underserved communities, the government can help provide a level playing field that gives all students a fair chance at success and contributes meaningfully to the growth and development of the country. We must prioritise education funding and support for rural schools to close the gap and ensure every child can thrive, regardless of where they live.

4.2. Theme 2: Enhanced Quality Education

In their view, the participants were asked to suggest solutions to implement SDG4. It was noted that significant numbers of participants concurred that AI can be used to achieve SDG4, and they recommended the following solutions. This theme was divided into personalised learning and inclusivity sub-themes.

4.2.1. Personalised Learning

The participant coded T5 argued that, in my view, *“AI could provide personalised learning experiences for students, identify areas for improvement in education systems, and make learning more accessible for all”.* Additionally, T5 emphasised the importance of investing in technology infrastructure and effectively training teachers to integrate AI into the classroom. It was also highlighted that AI's potential lies in *tracking student progress and providing timely feedback to students and educators.* By harnessing the power of AI, participant with the code name T3 believed that *education could be revolutionised to meet the needs of diverse learners better and prepare students for success in an increasingly digital world.* Ultimately, the participants in T2 expressed optimism about the transformative impact that AI can have on education when implemented thoughtfully and ethically.

The participants with code T5 noted that *leveraging AI in education could be crucial in advancing SDG4 and ensuring quality education for all.* It was also stated that unlocking the potential of AI can assist educators in identifying patterns and trends in student data to inform instructional decisions. Subsequently, there was a sense of excitement and eagerness to explore AI's possibilities for enhancing teaching and learning in schools worldwide. All six participants acknowledged the *need for continuous research and collaboration to explore AI's potential benefits in education while minimising possible risks.* They recognised the importance of ethical considerations such as data privacy and bias

and agreed to establish clear guidelines and regulations. Despite these challenges, the consensus was that *AI has the potential to revolutionise education and empower both students and educators in ways that were previously unimaginable*. The participants left the sessions feeling inspired and motivated to explore the possibilities of AI in education further and work towards a future where technology and learning go hand in hand.

4.2.2. Inclusivity

Another benefit of AI implementation in SDG4 is *the inclusivity of learners irrespective of their geographical location*, as highlighted by participant T2. With AI technology, learners from remote and underprivileged areas can access quality education and resources online, bridging the lacuna between urban and rural education systems. This increased inclusivity helps ensure that all learners, regardless of where they live, receive high-quality education that can empower them to reach their full potential and contribute positively to society. In addition, *the integration of AI in SDG4 has the potential to make quality education more accessible to all*, as reported by participant T6. *Implementing AI technology in SDG4 can analyse data on student performance and behaviour*, participant T1 stated. Also, AI can provide valuable insights to educators on how to better support and engage learners in their learning journey. This approach can lead to improved academic outcomes and a more engaging and fulfilling educational experience for learners. In addition, AI can assist educators in creating more interactive and engaging lesson plans, incorporating multimedia elements and adaptive learning technologies to enhance students' comprehension and retention. Participants in T4 pointed out that *leveraging AI technology in education can create a more dynamic and effective learning environment that meets the diverse needs of learners and prepares them for success in an increasingly digital and interconnected world*. By personalising the learning experience, AI can cater to individual student needs and learning styles, ultimately leading to higher engagement, achievement, and quality education. These AI tools can assist teachers in spending less time on administrative tasks and more time on providing specific feedback and support to students.

5. Discussion

This study delves profoundly using a phenomenological approach to explore AI for improving SDG4 in South Africa. By examining the lived experiences of educators, this research aims to unlock the potential benefits and pitfalls of integrating AI into the South African education system. Through in-depth interviews and educational data analysis, the study seeks to provide valuable insights into how AI can effectively enhance learning outcomes and achieve SDG4. To this end, the first theme of the study was titled unequal resource distribution. It was uncovered that inequitable access to quality education in rural areas, low academic achievement, and inadequate infrastructure, including textbooks, computer labs, and internet connectivity, were barriers to the successful integration of AI in the South African education system.

Additionally, concerns about the lack of teacher training and support in utilising AI technology effectively in the classroom were highlighted. This result corroborated the study of Lombo and Subban (2024), who reported some of these challenges bedevilling the South African education system and how they inversely affect the academic outcome of Grade 12 students. However, this problem is peculiar to South African high schools, and many African countries are battling similar situations. The issues of teacher training and support in utilising AI technology were other findings in this study and supported by Alwaqdani (2024); Celik et al. (2022). Without adequate training and support, educators may struggle to effectively integrate AI technology into their teaching practices, which can ultimately impact students' academic performance. This result aligns with the findings of Al-Zahrani (2024), who reported that many educators are not adequately trained to integrate AI into their teaching practices, which can lead to ineffective use of technology. As technology continues to

play an increasingly important role in education, addressing these challenges and providing necessary support to teachers will ensure successful implementation and positive outcomes in the classroom.

The last theme for the study is enhanced quality education. The participants unveiled several advantages, including providing a personalised learning experience for students, identifying areas for improvement in education systems, providing prompt feedback, and making learning more accessible for all. In terms of personalised learning experiences, many scholars have shown that AI can improve learners' individualised learning experiences (Kaswan et al., 2024; Maghsudi et al., 2021). AI can create individualised learning plans that cater to their specific needs and learning styles by analysing data on each student's strengths and weaknesses (Yekollu et al., 2024). This can result in a more engaging and effective educational experience for learners, ultimately leading to better academic outcomes (Ellikkal & Rajamohan, 2024; Mutambik, 2024; Opesemowo et al., 2024). Furthermore, by using AI to identify areas for improvement in education systems, schools and policymakers can make targeted interventions to address issues and improve overall performance. Overall, the benefits of AI in education are promising in advancing SDG4 and creating a more equitable and accessible learning environment for all.

6. Implications

Exploration of AI for improving SDG4 in South Africa offers valuable insights for policymakers formulating education policies. By understanding stakeholders' lived experiences and perspectives, policymakers can develop policies responsive to the unique challenges and needs of South Africa's diverse population. Moreover, policymakers can leverage AI-driven solutions to enhance the effectiveness of existing education initiatives and promote inclusive and equitable access to quality education. Educators play a crucial role in implementing AI-driven interventions in the classroom. The findings of this research can inform educational practice by guiding the effective integration of AI technologies into teaching and learning processes. Educators can use AI-powered tools to personalise instruction, provide targeted student support, and facilitate collaborative learning experiences. Additionally, insights from the phenomenological approach can enhance educators' understanding of students' lived experiences and learning needs, enabling them to adapt their pedagogical practices accordingly.

Adopting AI in education requires a skilled workforce capable of leveraging technology to support teaching and learning. This research has implications for professional development initiatives to build educators' capacity to integrate AI into their practice. Professional development programs can train educators on AI technologies, pedagogical strategies, and data literacy skills, enabling them to utilise AI-driven tools in the classroom effectively. Moreover, ongoing support and mentorship can help educators navigate the complexities of AI integration and adapt to evolving educational landscapes. Exploring AI to improve SDG4 in South Africa contributes to the broader research agenda on AI in education and sustainable development. This research can inspire further inquiry into the potential of AI to address complex societal challenges and inform the development of innovative solutions tailored to diverse contexts. Moreover, the phenomenological approach serves as a methodological framework for conducting research that prioritises the voices and experiences of marginalised communities, thereby promoting social justice and equity in educational research.

The findings of this research have implications beyond South Africa's borders and can inform global efforts to leverage AI for sustainable development. By sharing insights, best practices, and lessons learned, researchers, policymakers, and educators worldwide can collaborate to develop contextually relevant AI-driven solutions that advance SDG4 objectives. Moreover, international partnerships and networks can facilitate knowledge exchange and capacity building, fostering innovation and collective action in pursuing quality education for all.

7. Conclusion

Exploring the role of AI in advancing SDG4 in South Africa marks a critical step toward achieving inclusive and quality education. This study is grounded in a phenomenological approach, capturing the lived experiences of students, teachers, policymakers, and community members, revealing critical insights into the challenges and possibilities within the education system. The findings highlight AI's potential to personalise learning, enhance teaching effectiveness, and expand access to resources, particularly when aligned with social justice, equity, and sustainability principles. By integrating contextually relevant, AI-driven interventions, South Africa can address persistent educational disparities and empower learners to contribute meaningfully to society. The study underscores the necessity for policy innovation, teachers' capacity building, and continued research to fully harness AI as a transformative force for educational equity and sustainable development.

8. Recommendations

1. Tailor AI-driven interventions to South Africa's diverse communities' specific needs, challenges, and cultural contexts. Ensure that AI technologies are implemented in a way that respects local languages, traditions, and values to promote acceptance and efficacy.

2. Foster collaboration and co-creation among stakeholders, including students, teachers, policymakers, and community members, throughout the design, implementation, and evaluation of AI initiatives. Empower stakeholders to participate actively in decision-making processes and contribute their perspectives to ensure the relevance and Sustainability of AI interventions.

3. Address digital divide issues by ensuring equitable access to AI technologies and digital infrastructure, particularly in underserved and rural areas. Implement initiatives to provide students and educators access to devices, internet connectivity, and practical training on using AI tools.

4. Prioritise teacher training and professional development programs that build educators' capacity to integrate AI into their teaching practice. Provide ongoing support and resources to help teachers navigate the complexities of AI implementation and leverage technology to enhance student learning outcomes.

5. Develop guidelines and standards for AI's ethical and responsible use in education, emphasising transparency, accountability, and data privacy principles. Ensure that AI algorithms are unbiased, culturally sensitive, and aligned with human rights principles to prevent unintended consequences and promote trust in AI systems.

6. Establish robust monitoring and evaluation mechanisms to assess the impact and effectiveness of AI interventions on SDG4 outcomes. Collect data on key performance indicators, including access, equity, quality, and learner outcomes, to inform evidence-based decision-making and continuous improvement efforts.

7. Facilitate knowledge sharing and collaboration among researchers, practitioners, policymakers, and stakeholders at the national and international levels. Create platforms for exchanging best practices, lessons learned, and innovative approaches to AI integration in education to accelerate progress towards the SDG4 goals.

8. Ensure the long-term Sustainability of AI initiatives by integrating them into broader education reform efforts and institutionalising support structures within educational institutions and government agencies. Foster a culture of innovation, adaptability, and continuous learning to keep pace with technological advancements and evolving educational needs.

9. Limitations of the Study

While it was revealed that the benefits of AI in attaining SDG4 outweigh its pitfalls, the study recorded some significant gains. One of the limitations of this study is the use of qualitative data, which may not fully capture the scope and impact of AI in achieving SDG4. Also, the study's sample size was relatively small, which could have limited the generalizability of the findings. Future research would benefit from incorporating a larger sample size and utilising both qualitative and quantitative data to provide a more comprehensive understanding of the role of AI in achieving SDG4. Again, the short interview duration and the researchers' position may hinder the depth and breadth of the data collected. Further studies can adopt validated questionnaires and interviews to gather more robust data. Despite these limitations, the findings still offer valuable insights into the potential of AI in advancing SDG4. Moving forward, researchers should strive to address these limitations to provide a more robust analysis of the impact of AI on SDGs. By improving the methodology and expanding the scope of research, we can better understand how AI can be leveraged to effectively achieve SDG4 and contribute to a more sustainable future for all.

Declarations

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