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A comparative evaluation of the leadership development needs of basic school leaders in the 4.0 era

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School leadership development (SLP) in the context of the Fourth Industrial Revolution (4.0) is a crucial aspect of preparing basic school leaders to navigate the challenges and opportunities presented by the rapid technological advancements and changes in the modern world. The 4.0 is characterized by the fusion of digital, physical, and biological technologies, which profoundly impact various aspects of society, including education. Thus, this study examined basic school leaders' development needs in 4.0 in Nigeria and South Africa. A comparative research approach of survey design was adopted with the aid of a questionnaire. Descriptive statistics (mean score) and an independent *t*-test were used to analyze the collected data. Results indicated that basic school leaders in South Africa fared better than their counterparts from Nigeria regarding their 4.0 knowledge. However, no significant difference was found in 4.0 leadership skills. Leaders from both nations indicated the need for development programs in technological applications to enhance competency to perform their administrative tasks. In theory, the study addresses African schools' 4.0 leadership needs. To lead education into the future, each nation must also understand the specific 4.0 leadership skills its school leaders will need. In light of the study's findings, policymakers should consider what gaps need to be filled to equip their basic school leaders with Education 4.0 skills.

KEYWORDS

school leadership development, fourth industrial revolution, 4.0, technology, agility, 4.0 skills

Introduction

The COVID-19 pandemic has heralded the reality of education 4.0, which demanded a shift in school leadership. After the disruption caused by COVID-19 globally, school leaders engaged in rapid sense-making and change implementation processes to cope with the effects (Bush, 2023). As a result of the pandemic crisis, Gyang (2020) advocates adopting the Community-Based Education Leadership model by basic school leaders to promote effective teaching and learning. Furthermore, the pandemic resulted in school leaders having to learn new technologies and provide teachers with support in using these technologies to enhance teaching and learning (Müller et al., 2022; Abulibdeh et al., 2024; Saleem et al., 2024). In addition, education 4.0 requires an inclusive and nurturing learning environment, resources for learning, constructive feedback, and a vision of academic excellence (Yokuş, 2022; Moraes et al., 2023; Abulibdeh et al., 2024), thus creating a new model of educational leadership.

African education and the 4.0 are topics of significant importance for Africa's development (Ebekozien et al., 2024). The continent is actively working on aligning its education system with the demands of the digital age to equip its citizens with the skills and knowledge needed to thrive in the 4.0 era. Adapting African education to 4.0 will be crucial for the continent's economic growth and global competitiveness (Ebekozien et al., 2024; Raji et al., 2024). As technology advances, ongoing efforts to modernize the education system will remain essential. Despite these efforts, challenges still need to be addressed, including access to quality education in remote areas, funding constraints, and teacher and school leader training to effectively integrate technology into the classroom (Bayode et al., 2019; Awodiji and Katjiteo, 2023; Abulibdeh et al., 2024).

Africa and other continents are going through a tremendous world-shaking shift due to the emergence of Industry 4.0 (Mhlanga and Moloi, 2020; Mohamad et al., 2020; Alade et al., 2021). A four-dimensional industrial revolution (4.0) occurs when biological, physical, and digital technologies come together (World Economic Forum, 2017; Lee, 2021; Gadre and Deoskar, 2024). Aside from covering significant technological developments, 4.0 also covers robotics, 3D printing, artificial intelligence (AI), the Internet of Things (IoTs), quantum computing, automated systems, blockchain technology, biotechnology, battery technology, and nanotechnology (Falabiba et al., 2014; Lee, 2021). A significant component of Industry 4.0 is integrating the internet and emerging technologies, which will lead to an unprecedented paradigm shift in the world of work (Gürdür Broo et al., 2022). Industry 4.0's full potential depends on its ability to provide people with individualized expertise and skills. Educational institutions should address this challenge (Abulibdeh et al., 2024). Digital data integration in basic schools has been suggested to support dominant school administration and management cultures in the digital age by serving as a tool for (self)control (Selwyn et al., 2015). Thus, the need to assess and develop the digital capacity of basic school leaders to lead a successful school in post-digital era.

Leadership development in the 4.0 era has become increasingly important for basic school leaders due to the evolving educational landscape and technological advancements. School leaders need diverse skills to effectively navigate the challenges and opportunities the 4.0 era presents. Basic school leaders in the 4.0 era have some critical leadership development needs. Education 4.0 emerged in response to 4.0 and reflects the emerging demands in education, resulting in a change in pedagogy, culture, and managerial transformation of schools (Çetin and Karsantık, 2022). Thus, school leaders must possess relevant skills to lead schools in the 4.0 era. Uys and Webber-Youngman (2019) identfied several 4.0 leadership skills in the literature including critical thinking, creativity, problem-solving, people management, coordination with others, emotional intelligence, judgment and decision-making, service orientation, negotiation, cognitive flexibility, innovation, leadership, agility, adaptability, and resilience. In the industrial era of the 4.0, school leaders are expected to possess three qualities namely, the ability to engage in collaboration and human relations, the ability to think creatively and innovatively, and the ability to use learning tools per technological advances (Kin et al., 2020; Raksanakorn et al., 2022; Tetteh, 2022). To improve school leadership, Raksanakorn et al. (2022) identified five components which are, knowledge and ability, leadership skills, academic skills, morality and ethics, modern skills, and characteristics. Creative problem-solving, communication, digital literacy, intellectual, social, and coping abilities, and discipline knowledge are among the 4.0 skills (Chaka, 2020; Potokri, 2022). Leaders must embrace transformational, people-oriented, and charismatic leadership styles to thrive in 4.0 (Coopasamy and Botha, 2022). Moloi and Mhlanga (2021) identified the underlying elements driving 4.0 in education. It was found that South African education is not prepared for the 4.0 and that only a minority of school leaders were aware of 4.0 and its implications (Moloi and Mhlanga, 2021). Hence, school leaders must embrace 4.0 skills via professional development to survive in this changing era to lead a sustainable and successful school.

It is important for school leaders to receive professional development to keep up with the rapid changes in the world and continually improve their practice (Schleicher, 2012). Providing school leaders with appropriate professional development and acknowledging their crucial role in improving student achievement are critical factors in developing school leaders (Schleicher, 2012; Levin et al., 2020). Leaders in many schools reported having access to leadership-related training. Researchers have demonstrated that school leaders benefit from job-embedded professional learning because they can apply their learning on the job (Levin et al., 2020; Tetteh, 2022). Thus, the role of leadership development in the 4.0 era must be considered to lead successful schools in the changing era.

South Africa is the leading country involved in studies on leadership and 4.0. Other African countries have done scant research on the topic. Moreover, most South African studies focused on school leadership's role in adopting 4.0 technology. A balanced understanding of the topical area will require future research into other themes (Tetteh, 2022). Naidoo and Potokri (2021) investigated the leadership skills that female leaders in South African schools need to succeed in the 4.0 era. Adequate leadership development support needs to be improved in South African schools, preventing leaders from becoming 4.0-aligned (Naidoo and Potokri, 2021). The lack of 4.0 skills was a significant challenge facing South Africa in adopting 4.0 for education and economic development (Bayode et al., 2019). In South Africa, school leaders need opportunities to develop technology competencies, hardware skills, and 4.0 technology skills (Letuma, 2022). Despite their ability to install software, surf the internet for information, and use web tools to receive online information, school leaders needed help to create spreadsheets (Letuma et al., 2023).

In Ghana, schoolteachers' continuing professional development needs were explored amid current changes (Abakah et al., 2022). The study found that Ghanaian teachers need Information Communication and Technology (ICT) skills for effective teaching. In Nigeria, a study indicated that school leaders need more knowledge and skills in 4.0, 3D printing, AI, automation, and smart boards. In addition, school leaders need high competence in basic digital applications (Awodiji and Naicker, 2023). In performing instructional leadership responsibilities by school leaders, Awodiji O. A. et al. (2022) examined the e-supervision of instruction facilities in Nigeria and found that technologies are available to perform their supervisory roles in the changing learning environment. However, school leaders indicated that they require more training in using these e-facilities to perform adequate supervision (Awodiji O. A. et al., 2022). School leaders need opportunities to develop technology competencies, hardware, and 4.0 technology skills (Letuma et al., 2023). Despite their ability to install software, surf the internet for information, and use web tools to receive online information, school leaders needed help to create spreadsheets (Letuma et al., 2023).

Despite being prominent economies in Africa, particularly Sub-Saharan Africa, Nigeria and South Africa are different in terms of their economic and technological landscapes. An analysis of the 4.0 leadership development of Nigeria and South Africa offers a comprehensive picture of how different factors—economic, educational, policy-related, private sector-driven, and cultural—impact the development of basic school leaders capable of navigating the complexities of Industry 4.0 in these countries (World-Economic-Forum, 2022; UNESCO, 2024a,b). Therefore, comparative analysis can help identify best practices, challenges, and opportunities pertinent to each context. Furthermore, it contributes to more effective leadership development strategies tailored to their specific needs and circumstances.

Research questions and hypotheses

> Research Question 1: What knowledge of the 4.0 do school leaders in Nigeria and South Africa have?
>
> Research Question 2: How proficient are school leaders with technology applications in Nigeria and South Africa?
>
> Research Question 3: Do the school leadership skills needed to lead in the 4.0 differ in Nigeria and South Africa?
>
> *H01*: The country does not relate to how proficient school leaders with technology applications are in their administrative tasks.
>
> *H02*: School leadership skills needed to lead in the 4.0 is similar in Nigeria and South Africa.

Literature review

Theoretical framework

Human resources development theory (HCDT) in education is a multifaceted field that encompasses various approaches to enhancing human capital, skills, and knowledge within educational settings (Ross, 2021; Awodiji and Naicker, 2023). In a broader context, HRD theory focuses on developing individuals and groups within organizations, including educational institutions. HCDT, popularized by economists like Gary Becker, emphasizes the importance of education and training in increasing an individual's productivity and economic potential. It underscores the role of schools and training programs in developing human capital in education. It involves activities such as training, career development, and performance management. The theory focuses on how individuals make career-related decisions and how education plays a role in their career development. HCDT provides a framework for understanding how school leaders' development is integrated into the educational practices of a nation and the changing era. Also, it can contribute to school leaders' personal and professional growth in the post-digital space.

Skills development needs theory (SDNT), also known as "Skills Gap Theory," refers to a framework that helps identify and address individuals or groups' specific skills and knowledge gaps within an organization or a broader context (McCleland, 1985; Mehrabani and Mohamad, 2015; Obiakor and Newman., 2022; Abiola et al., 2023). It can be applied in various fields, including education, human resources, and workforce development. David McCleland, an American psychologist, propounded the SDNT. He is known for his research on motivation and personality, and he introduced this theory in the 1970s (McCleland, 1985; Mcclellan, 2022). The theory focuses on how an individual's motivation and achievement needs can be used to assess their skills development needs (McCleland, 1985; de Andrade Baptista et al., 2021). McCleland's work has significantly impacted the understanding of human motivation and skills development in various contexts, including education and the workplace. Key points related to skills development needs theory include assessment and analysis, identifying gaps, customization, goal setting, implementation, evaluation, adaptation, and benefits.

HCDT and SDNT apply to this study because they enable us to understand the importance of leadership development needs of basic school leaders in the era of 4.0 in South Africa and Nigeria. The role of training basic school leaders to lead the educational system in the era of disruption requires identifying their 4.0 skills and knowledge gaps. Thus, there is a need to evaluate basic school leaders' skills development needs in 4.0 to prepare them to lead sustainable schools. Going by the HCDT, identifying basic school leaders' 4.0 skills will promote the preparation of relevant educational programs that will increase their productivity and capacity to lead successful schools.

School leadership development

Effective leadership in schools is critical for student success, staff morale, and the overall functioning of the institution. As school leaders' responsibilities increase and their environment becomes more accountable-driven, leadership often takes center stage (Daniëls et al., 2019). School leadership is crucial to the success of individual schools and the achievement of educational goals (Hauge and Norenes, 2014; Acton, 2021). An effective school has strong educational leadership, an emphasis on acquiring basic skills, a secure and orderly atmosphere, high expectations of pupil achievement, and continuous assessment of student performance (Dinham et al., 2011). Thus, there is a need for school leadership development in the changing world to achieve a successful school. School leadership development (SLD) refers to preparing and empowering school leaders in basic school to become effective leaders. Basic school can encompass a variety of roles within a school, from teachers and principals to administrators and other staff members. However, in the study, school leadership focuses on principals, deputy principals, headteachers, deputy headteachers, and HODs. Leadership development in the context of basic education aims to improve leadership skills, enhance decision-making, and foster a positive school culture. Leadership development programs typically target individuals in various roles, including principals, assistant principals, department heads, and teachers who aspire to leadership positions.

Leadership development is an ongoing process, and many successful leaders continue to learn and grow throughout their careers. Leadership development often involves formal training, workshops, seminars, and courses that cover leadership skills, management, and educational leadership theories (Kasule et al., 2016; Sofo and Abonyi, 2017; Bellibaş and Gümüş, 2019). Universities offer some programs (Arikewuyo, 2009; Awodiji, 2018), while school

districts or educational organizations develop others (Singh et al., 2007; Mestry, 2017). A SLD program is a structured initiative to enhance school leaders' leadership skills and capabilities. These programs are typically created to identify and nurture leadership talent, promote professional growth, and improve effectiveness. SLD programs aim to identify, train, and mentor potential school leaders. They can help improve the leadership qualities of school leaders, such as communication, decision-making, problem-solving, and team management. Leadership development programs can improve employee morale, higher productivity, and a more skilled and capable leadership team. They can also aid in succession planning and ensure a talent pipeline for key leadership positions (Shyamsunder et al., 2011; Bush, 2012).

Among the approaches for leadership development is a mentorship program. Experienced leaders guide and mentor aspiring leaders to help them develop the necessary skills and insights (Bush, 2009, 2012; Gumus and Bellibas, 2016; Naidoo and Potokri, 2021). Many educators join professional associations and organizations offering resources, networking opportunities, and conferences on educational leadership development (Precey, 2009; Pont et al., 2010; Mestry, 2017). In addition, SLD programs often include workshops, seminars, coaching, mentoring, and experiential learning opportunities. Some may also involve assessments and feedback to help participants identify their strengths and areas for improvement (Mathibe, 2007; Bush, 2009, 2012; Gumus and Bellibas, 2016; Alade et al., 2021).

Education 4.0

In the late 8th Century, water and steam were introduced as sources of mechanical power to replace manual labor, resulting in the first industrial revolution. The second industrial revolution (2IR) was enabled by electrical energy and a better education system, which began in the 20th Century. Information technology began the third industrial revolution (3IR) in the early 1970s. Currently, cyber-physical systems define the convergence of digital, biological, and physical domains referred to as industry 4.0. Intelligent machines and seamless connectivity are not the only components of the 4IR, but so are genomics, nanotechnology, green energy, biotechnology, and stem cells (Spielvogel, 2005; Schwab, 2016; World Economic Forum, 2017; Oberer and Erkollar, 2018; Xu et al., 2018; Ilori and Ajagunna, 2020). The 4.0 education revolution brought about significant shifts in the educational system.

The 4.0 has had a significant impact on education. Learning and teaching have changed due to this revolution, featuring the integration of advanced technologies. The 4.0 education has seen technologies like AI, virtual reality, and IoT integration into educational practices (Siddiq et al., 2016; Baglama et al., 2022; Caleb and Eno, 2022). These technologies enhance the learning experience and provide new ways for students to interact with educational content. In addition, technology allows for personalized learning experiences.

Furthermore, technology facilitates self-learning. Adaptive learning platforms make education more effective and engaging for students. With the advent of 4.0, digital literacy has become essential (Stevenson et al., 2016; Didham and Ofei-Manu, 2020). School leaders, students, and educators must proficiently use digital tools, understand data, and navigate online resources.

Furthermore, the COVID-19 pandemic accelerated remote learning adoption, increasing online learning (Brock et al., 2021; Avidov-Ungar et al., 2023). The shift in learning space emphasized the value of digital infrastructure and online pedagogy. Consequently, 4.0 education emphasizes the need for analytical thinking, problem solving, innovation, and adaptability in the curriculum at all levels of education (Gibb, 2014; Makri and Vlachopoulos, 2019; Chaka, 2020). These skills are vital in a rapidly changing technological landscape. Moreover, technology has made it easier for students to connect with peers and educators worldwide. Global connectivity broadens educational opportunities and promotes cross-cultural understanding, aided by the 4.0 industry (Awodiji O. A. et al., 2022; Rasool et al., 2022; Vardy, 2022). In addition, the pace of technological change means that learning continues after formal education. Lifelong learning is essential to stay relevant in the job market and adapt to evolving industries in the post-digital era (Adarkwah, 2021; Gürdür Broo et al., 2022; Idris et al., 2022).

Fourth industrial revolution and education leadership skills

In the context of Education 4.0, schools' leadership plays a crucial role in shaping the future of education. Education 4.0 refers to integrating technology, innovation, and personalized learning in the education system. It is imperative that school leaders acknowledge the importance of their involvement in the adoption and use of technology. They should be adept at using technology and take the lead when it comes to using it for learning, teaching, and administrative tasks (Afshari et al., 2009). School leaders in the context of Education 4.0 are expected to involve others in the decision-making process to increase schools' effectiveness. School leaders should be involved in developing a curriculum that incorporates digital literacy, critical thinking, and problem-solving skills. They should ensure that the curriculum aligns with the goals of Education 4.0. As a result, leadership skills have evolved to meet the challenges and opportunities presented by this era. Essential leadership skills that are crucial for success in the 4.0 include adaptability and change management, digital literacy, innovation and creativity, collaboration and networking, data-driven decision-making, resilience, ethical leadership, global mindset, communication skills, emotional intelligence, sustainability and environmental awareness, and agility and risk management (Dinham et al., 2011; Keow Ngang et al., 2015; Negandhi et al., 2015; American Management Association, 2016; World Economic Forum, 2017; Tang, 2020; Alade et al., 2021; Hai and Van, 2021; Naidoo and Potokri, 2021; Letuma, 2022; Tetteh, 2022; Letuma et al., 2023). School leaders with these skills and knowledge are better equipped to navigate the challenges and opportunities presented by 4.0. They can help their schools thrive in this technological disruption and innovation era.

School leadership in Education 4.0 is about envisioning a technology-enhanced future for education, providing the necessary resources, training, and support to make it a reality, and continuously adapting to the ever-evolving digital landscape to prepare students for success in the 21st Century. To bridge the digital divide, school leaders must ensure technology accessibility for students and teachers (Komarova et al., 2019; Atasoy, 2022). Study by Johnson and Bartleson (2001) probed on how can media and technology experts within the

school assist school leaders in developing their technological skills? It was proposed that school leaders should receive customized training and technical support in addition to being included in all leadership development efforts related to technology.

School leaders are concerned with equity and inclusion skills, which involve addressing access, affordability, and digital skills development (Mango, 2018; Nishii and Leroy, 2022). Moreover, school leaders with digital citizenship have a role in promoting digital citizenship and online safety among students and teachers (Oberer and Erkollar, 2018; Makri and Vlachopoulos, 2019; Atasoy, 2022; Karakose and Tülübaş, 2023). Digital citizenship includes leading students and teachers in using technology responsibly and ethically. In addition, school leaders are to foster collaboration and partnership with other educational institutions, businesses, and community organizations to enhance students' and educators' exposure to real-world experiences and technology-related opportunities (Gibson et al., 2019). Education 4.0 is characterized by constant change and innovation. Thus, school leaders must be adaptable, creative, innovative, and open to new approaches and technologies to achieve better education outcomes. Leaders use data to inform their decisions, including student and staff performance data, which can help identify areas that need improvement and tailor teaching and learning strategies accordingly (Nkambule, 2020; Yokuş, 2022). Thus, there is a need for school leaders to be data-driven decision-makers to make informed and practical decisions that will promote sustainable education. School leaders are responsible for setting the vision and strategy for their institutions (McKimm and Swanwick, 2018; Karacabey et al., 2022). In Education 4.0, this involves envisioning how technology can be integrated into the curriculum, creating a digital learning environment, and aligning the school's goals with the demands of the digital age. All these require school leaders to be equipped with education 4.0 skills that will enable them to lead school in the post-digital era.

Methodology

This article compares two nations to provide readers with valuable insights, analysis, and a deeper understanding of the leadership development needs of basic school leaders in the 4.0 era. A comparative research approach of survey design was used in the study to establish differences and similarities in the 4.0 leadership development needs of basic school leaders of Nigeria and South Africa (Adiyia and Ashton, 2017). Comparative research was adopted to identify similarities and differences between Nigerian and South African school leaders in terms of their leadership development needs. Furthermore, policymakers can gain valuable insights by comparing policies, interventions, or practices across regions (Klein, 1991; Block, 1997; Afdal, 2019). In addition, it can help identify what works best for different situations.

In the study, Nigeria and South Africa were compared for 4IR leadership skills to identify patterns and trends and enhance cross-cultural understanding (Block, 1997; Azarian, 2011; Afdal, 2019). Inherently, this approach is limited by the cases chosen for comparison. Consequently, the findings may not apply to other cases not included in the study, limiting their generalizability (Azarian, 2011). Moreover, if cases are not chosen systematically or are not representative of the population under study, selection bias can result. As a result, conclusions can be inaccurate, and findings can be undermined (Block, 1997; Adiyia and Ashton, 2017; Afdal, 2019).

Study area

Of the nine provinces in South Africa, Gauteng Province, which is in the northeast, is the smallest but most densely inhabited. It contributes much to the GDP of the country and acts as the centre of South Africa's economy. Major cities in the province include Pretoria, the administrative centre, and Johannesburg, the biggest city in South Africa. The province is heavily urbanized. Gauteng is an important region for researching urbanization, economic development, and socioeconomic inequality because of its diversified population, dynamic economy, and well-developed infrastructure. Furthermore, its cultural richness, long history, and important role in the apartheid and post-apartheid periods offer insightful information for social science and historical studies. While Oyo state is one of the most historically significant states in Nigeria, which is located in the southwest of the nation. Ibadan, the state capital, is one of the biggest cities in Africa and a significant hub for trade and culture. Oyo State is a rich source of information for research on urban and rural dynamics, cultural studies, economic development, and the effects of modernization on socioeconomic inequality and traditional communities. Furthermore, its extensive history, diverse culture, and noteworthy. Ibadan has about 3.6 million people while Johannesburg is 5.7 million people in the metropolitan area. Fifteen districts made up of Gauteng Province while, Oyo state has 33 local government areas. Ibadan, being Oyo state capital city and metropolitan has 11 local governments.

The researcher purposively selected Nigeria and South Africa because they are in Sub-Saharan Africa. In addition, both nations are economic drivers of their regions, with South Africa to the South and Nigeria to the West. Furthermore, literature exists more in South Africa on 4.0 than in Nigeria, though they both lived in the world of 4.0. Similarly, both nations invest in human capital development to promote sustainable development and digitalization (Bayode et al., 2019; Donald, 2019; Ramaphosa, 2020; Caleb and Eno, 2022; Okeke, 2022). Ibadan and Johannesburg were purposively selected from the two countries because they are ranked 7th and 18th most populated cities in Africa (Kamer, 2023; WorldAtlas, 2024). Both cities are accessible to the researchers and diverse in their cultural and educational contexts.

A cluster sampling technique is useful when there is a large population and sampling a representative sample is not feasible (Turner, 2003; Acharya et al., 2013). However, the drawback is that the cluster method generally produces higher sampling errors than other sampling methods. Thus, a cluster sampling technique was used to select 505 school leaders from two randomly selected districts in Johannesburg, Gauteng Province, South Africa and 276 from four local government areas in Ibadan Metropolis, Oyo State, Nigeria (Petrillo et al., 2018; Shirdel et al., 2019). The cluster was used to select the two cities in Africa. Simple random sampling was adopted to assume homogeneity across all population segments in cluster sampling since clusters have high homogeneity within each selected cluster (Hahn et al., 2005; Tarter and Keuter, 2008). Thus, from each city (cluster), a random sampling technique was adopted to select schools from two districts in Johannesburg and four local government

areas from Ibadan Municipal to avoid bias (Turner, 2003). However, the participants were selected using a convenient sampling approach (Turner, 2003; Omodan, 2020). School leaders who are ready and willing to participate in the study were included in this study.

School Leadership Development Needs for the 4.0 (SLDN4.0) form was used. Items were rated on a 5-point Likert scale. We estimated the content and construct validity of the survey (Lawshe, 1975; Mohajan and Mohajan, 2017; Keller et al., 2020). As a result of the validation process, the questionnaire was revised to remove ambiguous phrases and texts. The content validity index (CVI) and content validity ratio (CVR) were computed based on panellist judgments. For all constructs, the CVIs were 0.83, 0.55, 0.78, and 0.81, respectively (Lawshe, 1975). The scale factors were established using parallel analysis with the R-studio package (Boateng et al., 2018; Daud et al., 2021; Nguyen and Waller, 2022). The scale factors were calculated using parallel analysis (Çokluk and Koçak, 2016). Before parallel analysis, the scale adapted 10 factors from the existing literature. In a parallel analysis, eight factors were identified, with items one and thirty not included under any of them. Pilot studies of the instrument were conducted in Ibadan and Johannesburg to determine its internal consistency. Survey items' reliability was estimated using Cronbach's alpha based on respondents' scores (Taber, 2018). Values above 0.70 are reliable (Pallant, 2011; Cohen et al., 2017). Thus, the scale is suitable for assessing leadership skills in schools.

Google Forms was used in South Africa to gather the data, which was then emailed to 600 school leaders. There were just 349 online answers obtained. Postgraduate students also helped visited the schools with 200 hard copies of the questionnaire and closely adhered to COVID-19 protocols to promote completion because the return rate was not adequate. Out of the 200 physical copies of the survey, the investigator was able to retrieve 156 copies along with two forms that were deemed useless. As a result, 505 school leaders in all responded to the study. In Nigeria, 400 hard copies of the questionnaire were distributed physically among school leaders, only 284 copies were returned. However, during data screening, only 276 completed responses from Nigeria were used. In total there are seven hundred and eighty-one school leaders. Before distributing the questionnaire, the researchers sought approval from the gatekeepers at the participating schools in Ibadan and Johannesburg. Participants' permission was sought before administering the questionnaires. A self-evaluation instrument was used to understand the school leaders' 4.0 leadership development needs.

Using the SPSS version 27 software package, their responses were analyzed descriptively (percentage, mean, and standard deviation) to answer research questions and inferentially (independent *t*-test) for hypotheses formulated.

Results

Table 1 showed that most (54.2%) participants were female. In comparison, 55.7% of them were selected from secondary schools' However, 58.0% of participants from South Africa were selected from primary schools, while 80.8% of Nigerian participants were selected from secondary schools. Heads of Department (HOD) constituted the most significant percentage (57.6%) of the participants concerning rank in their various schools; 39.2% of the total sample were bachelor degree holders, out of which 57.4% of participants selected from South Africa were honors degree holders, 47.8% of the Nigerian participants were bachelor degree holders. In comparison, only 1.0% were PhD holders. Regarding age distribution, participants of the age range of 41–50 years and 31–40 years were 32.1 and 29.8%, respectively, of the total sample; the lowest percentage of 15.1% was found among participants in the age range 25–30 years, while more than 75% of the total participant had at least 6 years and above of working experience.

> Research Question 1: What knowledge of the 4.0 do school leaders have?

As shown in Table 2, the weighted mean score of 2.2 is indicated for the Nigeria sample and 2.6 for the South African sample. This implies that while the school leaders from Nigeria possessed knowledge of the 4.0 to some extent, their South African counterparts possessed this knowledge to a large extent. However, concerning individual technology knowledge, the school leaders from Nigeria possessed knowledge about the Internet of Things (2.6 ± 0.9) and Information and communication technology (2.6 ± 0.9) to a large extent. In contrast, their South African counterparts possessed knowledge about the Internet of Things (2.8 ± 1.0), Information and communication technology (2.8 ± 1.0), and Smartboard (2.8 ± 1.0) to a large extent.

> Research Question 2: How proficient are school leaders with technology applications in Nigeria and South Africa?

In Table 3, given the technology applications proficiency weighted mean scores of 3.4 for the Nigeria sample and 4.1 for the South Africa sample, it is implied that the school leaders from Nigeria were at an intermediate level while the counterparts from South Africa were at an advanced level. Specifically, the school leaders sampled from Nigeria were at an advanced level of proficiency in performing some technology applications such as sending an email and surfing the internet to gather information, whereas, in terms of attaching a printer to a computer, creating a spreadsheet, editing a photo, downloading and installing software/apps, and using web tools to receive online information they were at intermediate level. As regards the school leaders sample from South Africa, they were at the intermediate level only in creating a spreadsheet. In contrast, they were at an advanced level in all other technology application tasks assessed in the study.

> Research Question 3: Do school leadership skills needed to lead in the 4.0 differ between Nigeria and South Africa?

Results in Table 4 showed that the school leaders selected from Nigeria expressed a preference for agility ($M = 3.5$, $SD = 0.9$), creativity ($M = 3.3$, $SD = 1.0$), and critical thinking and problem-solving ($M = 3.2$, $SD = 0.9$) as the leadership skills needed to lead in the 4.0 era while their South Africa counterparts expressed preference for critical thinking and problem solving ($M = 3.3$, $SD = 0.9$), communication expressiveness and collaboration creativity ($M = 3.1$, $SD = 0.9$), creativity ($M = 3.1$, $SD = 1.0$), information management and evaluation ($M = 3.1$, $SD = 1.0$), and agility ($M = 3.1$, $SD = 1.0$) as the leadership skills needed to lead in the 4.0 era.

TABLE 1 Socio-demographic characteristics of the school leaders.

Participant characteristics	Nigeria		South Africa		Full Sample	
	n	%	*n*	%	*n*	%
Gender						
Male	102	37.0	249	49.3	358	45.8
Female	174	63.0	256	50.7	423	54.2
Total	276	100.0	505	100.0	781	100.0
School level						
Primary	53	19.2	293	58.0	346	44.3
Secondary	223	80.8	212	42.0	435	55.7
Total	276	100.0	505	100.0	781	100.0
Rank						
HOD	108	39.1	342	67.7	450	57.6
Principal	34	12.3	94	18.6	128	16.4
Vice/Deputy Principal	99	35.9	69	13.7	168	21.5
Head Mistress/Master	18	6.5	–	–	18	2.3
Assistant Head Mistress/Master	17	6.2	–	–	17	2.2
Total	276	100.0	505	100.0	781	100.0
Highest qualification						
National Certificate in Education	29	10.5	–	–	29	3.7
Bachelor Degree	132	47.8	174	34.5	306	39.2
Honours Degree	–	–	290	57.4	290	37.1
Postgraduate Diploma (PGD)	50	18.1	–	–	50	6.4
Master Degree	57	20.7	41	8.1	98	12.5
PHD	8	2.9	–	–	8	1.0
Total	276	100.0	505	100.0	781	100.0
Age (years)						
25–30	20	7.2	98	19.4	118	15.1
31–40	50	18.1	183	36.2	233	29.8
41–50	71	25.7	180	35.6	251	32.1
51 and above	135	48.9	44	8.7	179	22.9
Total	276	100.0	505	100.0	781	100.0
Years of experience						
0–5	133	48.2	60	11.9	193	24.7
6–10	61	22.1	134	26.5	195	25.0
11–15	82	29.7	113	22.4	195	25.0
16–20	–	–	92	18.2	92	11.8
21–25	–	–	46	9.1	46	5.9
26 and Above	–	–	52	10.3	52	6.7
Missing	–	–	8	1.6	8	1.0
Total	276	100.0	505	100.0	781	100.0

Research hypotheses

> H01: Country does not relate to how proficient school leaders are with technology applications in their administrative task.

Result in Table 5 showed that difference in technology applications proficiency in tasks such as sending an email ($t = -8.62$, $p < 0.05$), attaching a printer to a computer ($t = -10.63$, $p < 0.05$), editing a photo ($t = -11.37$, $p < 0.05$), downloading and/ or installing software/apps ($t = -5.65$, $p < 0.05$), using web tools to

TABLE 2 Knowledge of 4.0 possessed by the school leaders.

S/N	Fourth industrial revolution knowledge (4.0)	Nigeria			South Africa		
		M	SD	Rmks	M	SD	Rmks
1	The Fourth Industrial Revolution (4.0)	1.7	0.7	*SE*	2.5	1.0	*SE*
2	3D printing	1.9	0.8	*SE*	2.4	0.7	*SE*
3	Internet of Things	2.6	0.9	*LE*	2.8	1.0	*LE*
4	Artificial intelligence	2.2	0.9	*SE*	2.5	0.8	*SE*
5	Information and communication technology	2.6	0.9	*LE*	2.8	1.0	*LE*
6	Automation	2.0	0.9	*SE*	2.2	0.8	*SE*
7	Smart Board	2.1	0.9	*SE*	2.8	1.0	*LE*
	Weighted Mean	**2.2**		*SE*	**2.6**		*LE*

Weighted Scale: 1.0–1.5 = Not at All (NA); 1.6–2.5 = Some Extent (SE); 2.6–3.5 = Large Extent (LE); 3.6–4.0 = Very Large Extent (VLE).

TABLE 3 Technology applications proficiency level of school leaders in Nigerian and South Africa.

		Nigeria			South Africa		
S/N	Tasks	*M*	*SD*	*Remarks*	*M*	*SD*	*Remarks*
1	Sending an email	4.1	1.1	*A*	4.7	0.7	*A*
2	Attaching a printer to a computer	3.4	1.4	*I*	4.3	0.9	*A*
3	Creating a spreadsheet	2.9	1.4	*I*	3.0	0.9	*I*
4	Editing a photo	3.2	1.3	*I*	4.1	0.8	*A*
5	Downloading and installing software/apps	3.3	1.2	*I*	3.8	1.1	*A*
6	Using web tools to receive online information (RSS feeds, Google+, LinkedIn, and Twitter feeds)	3.2	1.2	*I*	4.2	0.8	*A*
7	Surfing the internet to gather information	3.6	1.2	*A*	4.4	0.7	*A*
	Weighted mean	**3.4**		*I*	**4.1**		*A*

Weighted Scale: 1.0–1.4 = Novice (N); 1.5–2.4 = Basic (B); 2.5–3.4 = Intermediate (A); 3.5–4.4 = Advanced (A); 4.6–5.0 = Expert (E).

TABLE 4 Leadership skills needed by school leaders to lead in the 4.0.

S/N	4. 0 Leadership skills	*M*	*SD*	*Rank*	*M*	*SD*	*Ranks*
1	Agility	3.5	0.9	*1st*	3.1	1.0	*2nd*
2	Information management and evaluation	2.7	1.1	*5th*	3.0	1.0	*5th*
3	Communication, expressiveness, and collaboration	3.1	0.8	*4th*	3.1	0.9	*2nd*
4	Critical thinking and problem-solving	3.2	0.9	*3rd*	3.3	0.9	*1st*
5	Creativity	3.3	1.0	*2nd*	3.1	1.0	*2nd*
	Weighted mean	**3.2**			**3.1**		

receive online information ($t = -14.04$, $p < 0.05$), and surfing the internet to gather information ($t = -12.64$, $p < 0.05$) with higher and significant proficiency mean scores found among the school leaders selected from South Africa. However, no significant difference was noted in the technology application task of creating a spreadsheet ($p > 0.05$).

> H02: School leadership skills needed to lead in the 4.0 is not significantly different in Nigeria and South Africa.

The result in Table 6 showed that there were significant differences in school leadership skills needed to lead in the 4.0 as expressed by school leaders in Nigeria and South Africa about agility ($t = 5.22$, $p < 0.05$), Information management and evaluation ($t = -4.35$, $p < 0.05$), and Creativity ($t = 2.41$, $p < 0.05$) whereas; no significant difference was observed in skills like Communication expressiveness and collaboration ($t = -0.29$, $p > 0.05$), and Critical thinking and problem solving ($t = -0.57$, $p > 0.05$). School leaders from Nigeria placed more and significant emphasis on the need for

TABLE 5 *t*-test analysis of country difference in technology applications proficiency of school leaders.

S/N	Technology application task	Nigeria		South Africa		*t*(779)	*p*
		M	*SD*	*M*	*SD*		
1	Sending an email	4.11	1.09	4.66	0.68	−8.62	0.000
2	Attaching a printer to a computer	3.41	1.35	4.27	0.89	−10.63	0.000
3	Creating a spreadsheet	2.87	1.37	2.95	0.91	−1.01	0.313
4	Editing a photo	3.21	1.28	4.05	0.78	−11.37	0.000
5	Downloading and installing software/apps	3.33	1.25	3.81	1.07	−5.65	0.000
6	Using web tools to receive online information (RSS feeds, Google+, LinkedIn, and Twitter feeds)	3.21	1.18	4.21	0.80	−14.04	0.000
7	Surfing the internet to gather information	3.57	1.16	4.43	0.73	−12.64	0.000

TABLE 6 *t*-test analysis of country difference in school leadership skills needed to lead in the 4.0.

Leadership skills	Nigeria		South Africa		*t*(779)	*p*
	M	*SD*	*M*	*SD*		
Agility	3.52	0.92	3.13	1.03	5.22	0.000
Information management and evaluation	2.71	1.09	3.04	0.99	−4.35	0.000
Communication, expressiveness, and Collaboration	3.10	0.84	3.12	0.90	−0.29	0.768
Critical thinking and Problem solving	3.23	0.89	3.27	0.91	−0.57	0.568
Creativity	3.28	1.00	3.10	0.96	2.51	0.012

training on the agility, and creativity than their South Africa counterparts whereas; school leaders from South African expressed higher and significant needs for skills such as information management and evaluation as skills needed to lead in the 4.0 era. However, school leaders from Nigeria and South Africa are similar in their needs for training on communication and collaboration and, critical thinking and problem-solving skills.

Discussion of findings

The result in Table 1 indicates that Nigerian school leaders have some knowledge of the 4.0. However, their South African counterparts demonstrated considerable knowledge of the 4.0. The difference expressed by the school leaders could be related to factors such as government policy, the impact of global pandemics, national technological advancement and development, and cultural diversity. Consequently, school leaders should be informed of emerging digital opportunities (Apsorn et al., 2019). In this study, the findings confirm Bayode et al.'s (2019) contention that 4.0 skills are a significant challenge to South Africa's adoption of 4.0 in education. Nigerian school leaders also indicated that they needed more training in using these technological skills to perform their supervisory roles this corroborated the finding by Awodiji A. O. et al. (2022) that require additional training in using these e-facilities to perform adequate administration. Thus, school leaders' 4.0 knowledge should be improved upon via leadership development programs.

In contrast, Naidoo and Potokri (2021) found that South African schools must provide adequate leadership development support, preventing leaders from becoming 4.0-ready. Also, Moloi and Mhlanga's (2021) study revealed that in South Africa, only a minority of school leaders were aware of 4.0 and its implications. The difference between the current study and previous studies from South Africa might be informed by the time factor and orientation caused by the reality of the COVID-19 pandemic. To lead a sustainable school in this changing era, school leaders must embrace 4.0 knowledge through professional development regardless of the country type.

Among the school leaders surveyed in Nigeria and South Africa, Table 3 indicated that their level of proficiency is similar at an advanced level in sending emails and surfing the internet to gather and send information while intermediate in using spreadsheets. In contrast, the Nigeria sampled school leaders had intermediate skills in setting up a printer, editing a photograph, downloading software and apps, and accessing online information using web tools. At the same time, their South African counterparts are advanced in using these technology applications. Thus, it implies that school leaders from Nigeria must be trained to adopt these technology applications in carrying out their administrative tasks. Considering the role of school leaders in the

integration of technologies into education, Komarova et al. (2019) and Atasoy (2022) advocated that training and support should be made available to school leaders to continuously adapt to the ever-evolving digital landscape to prepare students for success in the 21st Century. To prepare school leaders for the 4.0, Letuma et al. (2023) stressed the need to upgrade their technological proficiencies. However, Table 5 indicated that significant differences exist between Nigeria and South Africa in the use of technology applications considered in the study, which favors South African basic school leaders.

Meanwhile, basic school leaders from the two nations have similar proficiency in creating spreadsheets. The findings supported the result in Table 3. Thus, Nigerian basic school leaders require training on adopting these technology tools to be at par with their counterparts from South Africa to lead successful schools in 4.0 education. The finding corroborates the result by Johnson and Bartleson (2001) that school leaders are not excellently proficient in the use of spreadsheet to carryout basic administrative tasks such as accounting, record keeping, and budgeting. In another study, a minority of school leaders indicated they were proficient in the database (6.7%) and spreadsheet (10%) software (Afshari et al., 2009). Thus, school leaders require training in the usage of excel sheets in a data-driven world.

Table 4 shows that school leaders selected from Nigeria indicated leadership development needs in agility, creativity, critical thinking, and problem-solving training to lead in the 4.0 education. In contrast, their South African basic school leaders preferred training on critical thinking and problem-solving, communication expressiveness and collaboration, creativity, information management and evaluation, and agility as the leadership skills needed to lead in the 4.0 era. Table 6 revealed that basic school leaders in Nigeria and South Africa expressed significant differences regarding the skills needed to lead 4.0 schools, including agility, information management, evaluation, and creativity. However, communication and collaboration skills, as well as critical thinking and problem-solving skills, were similar. Nigerian school leaders emphasize agility and creativity training needs more than their South African counterparts. Therefore, studies school improvement is significantly correlated with school leaders' soft skills (leadership ability, collaboration/teamwork, communication skills, initiative, Problem-solving skills, Critical skills, flexibility/adaptability, empathy, and emotional intelligence skills among others; Keow Ngang et al., 2015; Selwyn et al., 2015; Makri and Vlachopoulos, 2019; Letuma et al., 2023).

In contrast, school leaders from South Africa expressed higher and more significant training needs for information management and evaluation as skills needed to lead in education 4.0. However, the need for training in communication, collaboration, critical thinking, and problem-solving skills is the same between Nigerian and South African school leaders. The finding corroborated existing studies on leadership skills required to lead in Education 4.0 as adaptability, innovation and creativity, collaboration and networking, data-driven decision-making, resilience, ethical leadership, communication skills, emotional intelligence, agility, and risk management (World Economic Forum, 2017; Alade et al., 2021; Hai and Van, 2021; Naidoo and Potokri, 2021; Tetteh, 2022; Letuma et al., 2023).

Conclusion

This study compared the school leadership development (SLD) needs of Nigerian and South African school leaders for 4.0. An independent-sample t-test was conducted to compare the SLD needs of Nigerian and South African school leaders to lead. Compared to Nigerian school leaders, South African school leaders have significantly more 4.0 knowledge. School leaders needed help with using spreadsheets despite their proficiency with other technological applications. School leaders demonstrated moderate 4.0 leadership skills. 4.0 leadership skills (agility, creativity, and information management and evaluation) are varied by country type.

The assessment of school leaders' development needs helps identify areas for improvement and targets training programs accordingly. Individualized professional development programs are designed based on specific development needs. Furthermore, assessments facilitate collaboration and peer learning among school leaders by identifying common development needs. Through collaborative approach, best practices are shared, and a supportive professional community is fostered. As the educational landscape evolves, school leaders face new challenges. In order to address emerging challenges effectively, leaders must assess their development needs in order to remain agile and adaptable.

Implications of the study

It is therefore implied that, in organizing SLD programs for basic school leaders in Sub-Saharan Africa, the organizers or policymakers must consider basic school leaders' knowledge of 4.0 in leading sustainable development in the post-digital era. To achieve education 4.0, basic school leaders must acquire updated skills through SLD programs. According to the study, basic school leaders need capacity building to enhance their capacity to use IT applications, technology, and cutting-edge 4.0 technologies. They also emphasize spreadsheets skills needed to keep records in the data-driven world.

The South African Department of Basic Education and Nigerian Ministry of Education must organize extensive training for basic school leaders to increase their understanding of the education 4.0 attributes. In response to the findings, educational agencies and private donors should provide SLD programs so that basic school leaders can learn different 4.0 skills and knowledge in collaboration with other school leaders. The Nigerian government can copy the South African government in implementing Education 4.0 to drive education in a changing world.

To prepare school leaders for the demands and requirements of 4.0, private individuals and policymakers must understand the significance of equipping basic school leaders with 4.0 competencies and allocate resources accordingly. Based on the study's findings, it is recommended that the Ministry of Education consider the gaps that need to be filled to empower their basic school leaders with the competencies required for Education 4.0.

Theory-wise, the study addresses African schools' 4.0 leadership needs. It is also essential for each nation to realize the specific 4.0 leadership skills its school leaders will need to lead education into the future. To gain insight into the leadership development needs of basic school leaders in the era of 4.0 in South Africa and Nigeria, the

HCDT and SDNT theories are applied. A key aspect of school leadership development is identifying the skills and knowledge gaps that need to be addressed as the educational system adapts to a disruptive era. School leaders should be prepared to lead successful schools in the changing world by identifying 4.0 skills development, according to HCDT.

Limitations of the study

The study had limitations. A total of two cities, one from Nigeria and one from South Africa, were included in the sample. As a result, the findings cannot be generalized across the two nations. Methodologically, the study is limited to surveys which may not provide in-depth understanding of school leadership development needs. Thus, a qualitative approach could be adopted to have in-depth understanding of what school leaders' professional development needs to lead effectively in 4IR in the future studies. The adoption of cluster sampling also poses limitations to this study. Because sampling bias compromises external validity, namely population validity, findings are not generalizable. The results could have been affected by the proportion of Nigerian and South African school leaders who answered the questionnaire. Some 4.0 leadership skills like empathy, emotional intelligence, adaptability, social intelligence, flexibility, ethics, and AI skills should have been studied. School leaders' 4.0 leadership was not linked to the effectiveness of their schools in this study. As a result, further research can be conducted to determine whether school effectiveness is affected by 4.0 leadership competence. This study can be replicated in other regions of Africa to have comprehensive leadership development needs of the basic school leaders in the continent of Africa since this current study was limited to Southern and Western Africa countries.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the patients/participants or patients/participants legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

OA: Conceptualization, Formal analysis, Investigation, Methodology, Resources, Validation, Writing – original draft, Writing – review & editing. SN: Conceptualization, Resources, Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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