E-Learning Supporting Infrastructure Investment in South Africa: Perspective of a Developing Economy

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Abstract: South Africa is one of the developing economies. Most of its provinces are in rural areas and have poor or lack of reliable critical infrastructure to enable development as in the case of urban areas. Infrastructure refers to physical structures that serve as the underlying foundation for the functioning of an economy. It includes physical facilities such as communication systems (telephone lines, broadband), and power supply systems (electrical grids, dams, etc.). The focus of the study is on information communication technological infrastructure (ICT) such as telephone and broadband networks and electricity infrastructure that support the adoption of e-learning. Many schools in South Africa are in rural areas and are attended by the majority of learners. These learners should perform the same way as learners in urban schools. Urban schools have better access to ICT infrastructure. Due to a lack of equitable ICT infrastructure, many education institutions back-tracked from the hybrid teaching mode implemented during the coronavirus (COVID-19) lockdown to the traditional class/lecture-room mode of teaching. It is revealed in the study that South Africa struggles in the area of infrastructure development. These affect the achievement of sustainable development goals (SDGs) which are heavily dependent on infrastructure, including education. E-learning offers a better advantage compared to traditional class/lecture-room-based education. ICT infrastructure that supports the provision of e-learning is not equitably distributed, and those that are available are not enough and reliable. South Africa is reported to need R4.8 trillion to achieve its critical infrastructure goals, indicating a dire need for infrastructure investment. Under-investment in infrastructure affects all sectors of the economy, including the education sector.

Keywords: Distance education, e-Learning, Infrastructure development, Infrastructure crime (theft and vandalism), Internet connectivity

1. Introduction and Background of the Study

Education is fundamental for all economies to grow and prosper. It is a tool for individuals to realise their full potential (Partner, 2022), a tool most powerful to change the world. The need for the world to change is more urgent and greater than ever. An investment in education is fundamental in paving the way to achieving sustainable developmental goals (SDGs) (Kioupi and Voulvoulis, 2019). Education allows communities to discover themselves, localise, and ultimately progress in achieving their aspiring priority SDGs (Kioupi and Voulvoulis, 2019). Education is the pillar of SDG#4, one of the 17 SDGs (Thacker et al, 2019). The purpose of education, regardless of the format it is offered (e-learning, mobile learning, face-to-face), includes servicing economies and developing and supplying human capital (making students/graduates employable) (Traxler, 2018). The United Nations (UN) 2030 agenda for sustainable development is fundamentally a universal commitment to peace and prosperity while preserving the planet. South Africa is rated in position 113th out of 161 countries on performance in the achievement or progress made towards the achievement of the SDGs. Most developing nations, including South Africa, are not doing well toward achieving SDGs (Creamer Media Reporter, 2024). The performance of most African countries is held back by spending more resources on servicing foreign debts than on investment in infrastructure that supports the achievement of SDGs, including education (Thorne, 2024). Infrastructure is at the center of support for the achievement of most of these 2030 SDGs' agenda, including education, electricity, and digital/ICT (Developmental Bank of Southern Africa (DBSA) and The World Bank, 2023). There is a dire need to invest, operate, and maintain the infrastructure required to achieve these SDGs in South Africa, including SDG#4 for education. The available public resources to close the infrastructure gap are not enough to meet the demand for infrastructure investment (Developmental Bank of Southern Africa (DBSA) and The World Bank, 2023). In South Africa, the infrastructure that should facilitate and support the provision of quality online learning (e-learning) is not enough, and those that are available are reliable or stable. For example, it is reported that load-shedding causes havoc among network service operators, especially when higher stages of multiple power outages are implemented in a day (Staff Writer, 2024). When a power outage hits the area, the internet connectivity is severely affected, both for businesses and households (Staff Writer, 2024). Quality education is at the center of the formulation of a common vision which is guided by the SDGs. It capacitates stakeholders (educators, learners, and communities) to identify constraints and enabling conditions, work together to select the needed competencies, develop appropriate curricula and pedagogies, pursue the many facets of a whole-institutional approach, and evaluate their progress made towards sustainability of well-articulated goals (Kioupi and Voulvoulis, 2019).

The future is becoming increasingly uncertain, a concern is whether the education system adequately prepares students for the world they will inherit, given the huge investment in education (Partner, 2023). The capacities of many countries in attending to uncertainty were tested during harsh Coronavirus (Covid-19) on the poorest, most vulnerable, and marginalised communities (Reddy and Mncwango, 2021). In the area of education, the transition to distance learning revealed some gaps, unjust inequities, and digital divides in the provision of quality education (Reddy and Mncwango, 2021). The future job market may look different from what it is today. Instead of trying to pre-empt how and what the future of work will look like, important skills such as resilience, critical thinking, and problem-solving should be taught and prioritised on (CambriLearn, 2023; Partner, 2023). E-learning is capable of equipping future-ready graduates, who harness these necessary life skills and tools for thriving in uncertain times (CambriLearn, 2023; Partner, 2023). Education helps countries to be forever prepared for uncertainties by investing in human resource development by capacitating people, versatile to address most of the pertinent challenges brought by the uncertainty of the future.

The infrastructure that supports the provision of quality services such as education for the future is not stable and reliable. It is due to factors such as theft, vandalism, and corruption among other factors which impede investment, operation, and maintenance of these infrastructure. Many resources are used in operating, maintaining, repairing, and replacing the stolen and vandalised infrastructure. The transition from old infrastructure has not been a smooth one, resulting in the unstable provision of the most needed commodities such as electricity among others. All these are problems that should be confronted head-on if the country wants to compete with the best in the world. Corporations are also concerned about most of these challenges. There are needs and importance of South Africa to invest in education for the youth (Parker, 2023). The world's highest failure rate of small and medium-sized enterprises (SMEs) is largely due to the failure of South Africa to invest in people at all levels of society (Parker, 2023). The failure of public education, lack of infrastructure epidemic lawlessness, and continuous failure of public health care in South Africa were lamented on (Parker, 2023), widening the gap between inequality and a high rate of unemployment (Madubela, 2022). The areas of reform such as infrastructure investment, accessible to reliable and predictable energy supply as the fourth means of production. South Africa is not poor, and Africa as a continent is not also poor but is simply poorly governed (Madubela, 2022). Many reports suggest that South Africa is struggling in the areas of infrastructure investment, operation, and maintenance. These affect the achievement of the sustainable developmental goals (SDGs) commitments with the United Nations 2030 agenda, these include education. Education is responsible for developing and supplying human resource capital capable of influencing the achievements of other sustainable development goals. The study reviewed the literature to discover the relationship between infrastructure investment, operation and maintenance, and attainment of education, as one of the pillars of sustainable development goals. In the next sections, the aspects of e-learning and infrastructure investment/development are focused on and discussed accordingly.

2. E-Learning (Theory) Principles and Practices

The concepts of electronic learning (e-learning), mobile learning (m-learning), and digital learning (d-learning) are somehow used indifferently, or in a complementary way to mean technologically supported learning (Sujit et al, 2018). E-learning is the alternative to traditional education and it also complements it (when the hybrid approach is used (online and face-to-face classroom)). On the other hand, m-learning is complementary to both traditional face-to-face classroom/lectureroom-based learning and e-learning. M-learning allows learners to interact with their learning resources while far away from normal learning environments. Through m-learning, students can easily perform certain support activities such as buying or downloading e-books to their devices. It is no longer a novelty for learners, but it is a mainstream, pervasive learning delivery medium relied upon by thousands of tertiary education institutions, including millions of workforce in various workplaces. M-learning is the subset of e-learning. E-learning is a macro concept that includes m-learning, d-learning as well as all forms of online learning environments. M-learning is e-learning through mobile computational devices, such as Palms, and even digital cell phones (Sujit et al, 2018). D-learning is a tool that addresses numerous challenges that are faced by educational institutions, community leaders as well as policymakers. It helps learners to connect in remote areas with the institution – and career-prep courses taught by a qualified instructor who does not work in the students' institution. It is helpful for instructors who are facing some barriers in meeting student's learning needs. The use of these technical terms sometimes confuses users in drawing some distinctions among them (Sujit et al, 2018). E-learning or distance education is progressively chosen for students in higher education institutions for the convenience it offers both instructors and learners. It is the delivery of educational activities (all activities relevant to instructing, teaching, and learning) through various electronic media (Koohang et al, 2009). According to Rodrigues et al (2019), there is no commonly

accepted definition for e-learning, describing it as a broader approach to learning that brings new opportunities for learning and teaching in many fields of education far from the conventional traditional lecture-room environment (Rodrigues et al, 2019). Digital technologies (artificial intelligence (AI) and the Internet of Things (IoT)) are the main factors for trends for education in the public domain for meaningful lives through employment in the economy (Traxler, 2018). Distance learning exists in the wider context characterised by global technological development, economic trends, and exerted pressures against specific educational technology trends and initiatives which are fragmented and diversified (Traxler, 2018). The literature describes distance education as implying the physical separation between the student and an instructor, which is not the defining feature of e-learning. The concept of distance education has evolved into other forms of learning, such as e-learning, online, online collaborative, and virtual web-based learning (Rodrigues et al, 2019). The most common feature of all these forms is that instruction occurs between a student and an instructor at different times and/or places, using several forms of gadgets. There are four general categories proposed for the elements of e-learning, including technology-driven (emphasizing the technological aspects of e-learning); delivery-system-oriented (focusing on the accessibility of learning resources); communication-oriented (considering e-learning to be a communication, interaction, and collaboration tool); and educational par e-learning as a new way of learning or as an improvement on an existing educational paradigm) (Rodrigues et al, 2019). In the main, e-learning is commonly defined as focusing on either one or more of these four general categories. In general, the most common definition of e-learning is education supported by information communication technology (ICT) to enable access to online learning/teaching resources (Rodrigues et al, 2019). These forms of provision of education mirror the world of work, aiding in the development of human capital ready for jobs of the future as the world of work continues to evolve and increasingly uncertain.

There is another education concept referred to as homeschooling or learning from home, which is also supported by most electronic and technological gadgets, offering vast advantages and benefits such as less mandatory travel to an education institution, ownership of time, or managing one's own time by pacing with oneself's learning speed (CambriLearn, 2023). However, homeschooling has strong effects on the inequality in educational opportunities and other related challenges (Bol, 2020). South Africa would be on its way to achieving better infrastructure, but most infrastructure investment, operation, and maintenance are affected by issues of theft and vandalism, and corruption, with more resources spent on maintenance and replacing missing ones (Mputing, 2022). Some nations such as the United States of America (USA) with advanced network and broadband infrastructure, realising that the country's traditional education system was outdated, visualised and implemented a nationwide digital transformation initiative for the education sector. They created the world's biggest digital library, one that was inspired by the entire nation and would be used by all citizens to empower them for a better future (Partner, 2022). In homeschooling, parents assist learners with the process of learning, facilitated by e-learning. The South African government is at a stage of drafting the artificial intelligence (AI) policy, drawing lessons from international practices to both stimulate AI development and effectively address associated harm and ethical risks (Thorne, 2024). At this stage, other countries are making progressive strides while South Africa is still contemplating policy development on current issues such as AI. These are the trends that are defining the educational and world of work environments.

3. Investment in e-Learning Enabling Infrastructure

An analysis of the history of empires and successful nations shows that one of the primary defining features of their success was scientific discoveries and investment in technological innovations and development (Luthuli, 2023; Saidi et al, 2018). South Africa might not be in the process of building an empire but needs to build a viable economy, feed and educate its citizens, create jobs, and build, maintain, and operate infrastructure. Infrastructure plays a major role in people's lives. Infrastructure is the physical structure that serves as the underlying foundation for the well-functioning of an economy. These include physical facilities such as transportation systems (rail, roads, airports, etc.), communications systems (telephone lines, broadband), power systems (electrical grids, dams, etc.), and water provision and treatment (e.g., irrigation and sewage), and buildings that support production and human capital development, office structures, factories, schools, and hospitals (Kapsoli et al, 2023; Luthuli, 2023). The concept of infrastructure has been extended to various spheres, such as institutional infrastructure, financial infrastructure, and so forth (Kapsoli et al, 2023). There are interdependencies and complementary existence of infrastructure in various economic sectors for an integrated service provision (Creamer Media Reporter, 2024). Adequate infrastructure across all economic sectors is required and it is a necessity for achieving sustainable development goals (SDGs).

A recent global report on infrastructure needs by the World Bank concluded among others that the focus should not only be on spending more but spending better on properly managing and maintaining the existing infrastructure (Developmental Bank of Southern Africa (DBSA) and The World Bank, 2023). The amount of financial resources required for infrastructure that keeps the lights on is estimated between R200 and R350 billion over ten years. There is a challenge in raising these funds, with a proposal for the participation of the private sector (Fraser, 2024). The point is that infrastructure is intimately intertwined and interwoven for the well-being of citizens by permeating most aspects of their daily lives (Luthuli, 2023). Infrastructure can be described as a system that organises and manages complex systems of flows, movements, and exchanges of services. Infrastructure does not only provide networks of pathways, but also provides locks, gates, and valves to check, control, and regulate these flows (Saidi et al, 2018). An integrated infrastructure system can be described as a combination of two or more infrastructure systems working together with an explicit awareness of one another through combinations of spatial, physical, logical, and/or cyber connections (Saidi et al, 2018). Integration can occur at various scales (e.g. urban, rural, or regional) and across the ecosystems (e.g. social, urban, land, water, and climate) and between different structures or sectors (e.g. social, physical, health, economic, and political). Traditionally, infrastructural development was planned, designed, operated, and managed independently of the other. The integrated infrastructure systems are preferred because of the common factors/drivers, such as information and technological innovation, risk of failure due to age, economic/population growth, extreme events, and climate change (Saidi et al, 2018).

When there is no service delivery supporting infrastructure, people protest, demonstrating how infrastructure contributes to their social lives (Luthuli, 2023). Infrastructure is part of sustainable development goals (SDG#9) (industry, innovation and infrastructure). It is recognised to have much wider benefits for sustainable development goals, either directly or indirectly influencing all other 17 SDGs, including 121 of the 169 SDGs' targets (approximately 72%), including education, and energy supply among others (Thacker et al, 2019). One of the reasons infrastructure is not appreciated is because of it quiet role it plays in the background. People fully appreciate the significant value of infrastructure when something goes wrong with it. For example when there is no electricity, water, connectivity, etc (Luthuli, 2023). Some of the Johannesburg Stock Exchange (JSE)-listed company chief executive officers (CEOs) called out for the government's failure to provide solutions on an ever-increasing list of issues, including power crisis, coupled with the deteriorating logistics industry, infrastructure vandalism, record-levels of unemployment and rising poverty, policing, service delivery, among others (Dludla, 2023). Various economic industries such as the mining and automotive industries share the same sentiments about the unsustainable cost of doing business in South Africa, attributing these to load-shedding, deteriorating rail infrastructure, and inefficiency of the ports (Manyane, 2023). It is lamented that each time load shedding is implemented, approximately 1% of the gross domestic product (GDP) is wiped off the economy. This affects the future and well-being of all South Africans, with increasing job losses, economic instability, and a decline in the quality of life (Dludla, 2023; Manyane, 2023). In response to the high cost of transport logistics and ongoing load-shedding, some mining giants had to shut down their businesses, cutting many needed jobs. Domestic challenges are also coupled with global challenges, such as the global weak demands of some of the mining produce (Dludla, 2024). According to SEDA (2023), the forced roll-out of green energy projects to mitigate the impact of emission footprint may give South Africa an advantage over time. The early adopters of these frontier technologies can move ahead faster and create permanent advantages for themselves than the scepticals. South Africa is ranked 56th out of 166 countries, in these fields as per the calculated frontier technology readiness index, focusing on information communication technology (ICT) skills, research and development, industrial capacity, and finance indicators, well ahead of all its sub-Saharan African peers. The improvement of the education throughputs (science, technology, engineering, and maths field) is emphasised as one of the tools for South Africa's improved readiness (SEDA, 2023).

According to Malatji and Baloyi (2023), it's proven that unstable power supply or power outages not only affect the economy and socio-economic aspects of society but destabilise internet connectivity, which is one of the main enablers of online learning. Load shedding is described as another pandemic in the South African context. Effective online learning in South Africa is hamstrung by the frequent load-shedding, which is blamed for poor internet connectivity-related services (Malatji and Baloyi, 2023). Other factors that are contributing to the poor development of e-learning, in addition to load-shedding, are factors such as the digital literacy gaps, shortages of personal laptops, and exposure to contemporary fields such as marine studies (Malatji and Baloyi, 2023). Infrastructure should enable a reliable power supply, which is fundamental in creating an environment for effective online learning to take place. An environment that allows students to concentrate on their studies with fewer major obstacles such as lack of necessities like power supply, digital skills, and connectivity is desirable (Malatji and Baloyi, 2023). The effective transitioning of open distance learning institutions from

conventional print-based learning is leveraged by digital devices such as computers, iPods, mobile phones, and other emerging technologies, in the heart of all these is a seamless connectivity (Msekelwa, 2023). In a world driven by technology, South Africa battles with power load shedding, sending some unprecedented shockwaves against effective and efficient development in the education landscape (Mbaleki et al, 2024). Load-shedding leads both students and lecturers to only connect outside normal working hours, especially in rural areas (Mbaleki et al, 2024). The impact of these challenges could be witnessed in the unprecedented rise in unemployment, as the impact transcends to affect other economic sectors, such as the provision of quality education.

According to Cowling (2024), there were 45.34 million active internet users in South Africa as of January 2024. These numbers represent a significant growth of internet users up from 25 million in 2013. 26 million internet users in the country use social media, which is approximately 42.8% of the total population. The majority of these people, approximately 78.7% are using mobile devices to access the internet, with those aged between 25 and 34 years being the highest users (Cowling, 2024). These developments were positive as internet users in South Africa averaged 72% globally, with the Sub-Saharan averaging 36% (WorldBank, 2024). Some reports indicate that South Africa is the most internet-addicted country, with users spending a staggering average of at least 9.5 hours online per day, surpassing the world average of 3 hours (Rédaction Africanews with Agencies, 2023). The problematic use of the internet (PUI) constitutes a serious health concern among users, especially those aged between 18 and 30 years in South Africa (Van Den Berg, 2022). The percentage distribution of households with access to the Internet at home or through all means for periods between 2010–2022 is shown in Table 1 below:

Table 1: Percentage of households with access to Internet at home or mobile between 2010–2022

Connectivity	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Home/fixed	10.6%	10.2%	10%	10.3%	11.1%	9.9%	9.8%	10.6%	10.4%	9.1%	8.3%	10.4%	13%
Anywhere	28%	34.4%	41%	41.3%	49.2%	54.1%	59.8%	61.8%	64.7%	63.3%	74.1%	77.5%	75.3%

Source: (StatsSA, 2024)

Connectivity in most cases is through mobile gadgets rather than at home. Home connectivity averaged 10%, with mobile connectivity high above 75% (StatsSA, 2024).

Trends in South African education highlighted steady, but insufficient progress has been made in educational attainment. The data shows significant increases since 1994 in attainment of secondary education, especially amongst black Africans. Despite all these positive reports, large inequalities between different population groups remain concerning with the transition from secondary education to the completion of a bachelor's degree. Education and other authorities have achieved a lot in increasing primary and secondary school attendance rates with interventions such as the provision of free education, free meals, free transport, social grants, and financial aid (National Student Financial Aid Scheme (NSFAS)) for students pursuing higher education. Further improvements in the quality of education are needed, through interventions such as smaller classes and better-trained teachers (StatsSA, 2024).

Unemployment has been on the steady increase with the prevailing deterioration of infrastructure as shown in Table 2 below:

Table 2: Unemployment rate by sex, Q2: 2015 to Q2: 2023

Period	2016	2017	2018	2019	2020	2021	2022	2023
	Q4	Q4	Q4	Q4	Q4	Q4	Q4	Q4
Women	28.9	29	29.5	31.3	34.3	38.2	35.5	34.4
Men	24.5	24.8	25.1	27.2	31	32.8	30.4	30.1
Below matric	31.2	31.8	32.0	34.6	37.9	39.8	38.9	38.6
Matric	27.1	27.5	28	29.7	33.9	37.7	34.4	33.7

Period	2016	2017	2018	2019	2020	2021	2022	2023
	Q4	Q4	Q4	Q4	Q4	Q4	Q4	Q4
Graduates	7	6.6	6.7	7.6	8.4	11.8	10.6	9.6
RSA	26.5	26.7	27.1	29.1	32.5	35.3	32.7	32.1

Source: (StatsSA, 2024)

In 2016, unemployment was at 26.5%, with women at 28.9% and men at 24.5%. This has since increased steadily to 32.1%, with women at 34.4% and men at 30.1% in 2023, fluctuations only focused on quarter four of every year. Women are the most affected group than their male counterparts (StatsSA, 2024). Unemployment was also severe among those with minimum education, such as fewer matriculants as compared to matriculants and graduates. However, unemployment is on the increase among all groups (graduates, matriculants, and less matriculants) (StatsSA, 2024).

4. In Conclusion

The study shows the interface between infrastructure investment, maintenance and operation, and progressive development in education. Infrastructure is at the heart of economic development, facilitating the achievement or progress towards the achievement of the SDGs, including education SDG#4. In the absence or lack of infrastructure investment, operation, and maintenance, the economy struggles to achieve or advance toward the advancements of the other SDGs. Education, which is responsible for the development and supply of human capital, also suffers when there is a lack of or under-investment in infrastructure, maintenance, and operations. These compromise the overall achievements of objectives of the universal sustainable development for peace and prosperity. The other social challenges, such as high unemployment rates reach unprecedented levels, rendering the country difficult to govern. Both the corporate and academic community, share the same sentiments that there is an urgent need for investment in infrastructure. The provision of quality education also suffers in that, the education that is provided, does not adequately prepare graduates for the future world of work. The fact that there is high unemployment among graduates, is a sign that the current education system is not adequately preparing graduates for a future-ready world of work. Unemployment is high amongst the youth, suggesting that the education that they received, does not give them more options, either to look for a job or create one for themselves and contribute to the economy.

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