Charting the Future: Digital Technologies and the Transition of South Africa's Education System

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Abstract

This study aims to understand the transition of South Africa's online education system through an examination of niche digital technologies. While previous studies have mainly centered on Information and Communication Technologies for e-learning, this research explores emerging digital tools of the Fourth Industrial Revolution to understand how they are shaping education in the country, within the context of enhancing student engagement online. Using a Multi-level Perspective (MLP) framework, this study explores the dynamic interactions among various factors that contribute to shaping online education in South Africa. We evaluate the landscape developments taking place in the system, the existing socio-technical regime, and several digital technologies at the niche level. The findings indicate that at the regime level, there are various stakeholders, including schools and governmental regulatory bodies. The dominant technology in this system appears to be ICT. Externally, factors such as the COVID-19 pandemic and increased educational demands are pressuring the existing education system, while specifically concerning online education, factors such as the lack of student engagement and interaction further destabilize the system. This pressure and destabilization of the regime create opportunities for niche technologies such as the Metaverse, Holographic technologies, and XR to diffuse into the mainstream, enhancing student engagement and interaction. However, integrating these niche technologies faces challenges such as unequal internet access, privacy concerns, hardware and software requirements, and the existing digital divide. Recognizing how niche digital technologies can enhance students' engagement and cause a transition in the education system, educators and policymakers can adopt more deliberate strategies for their integration. This can lead to more interactive learning settings that meet the changing needs of students in today's digital world. The study introduces a conceptual framework for understanding the transition of the education system through the disruptive influence of niche technologies, adding unique insights to the existing literature.

Keywords: *E-learning, Digital technologies, Metaverse, Holographic technology, Education, Multi-Level Perspective*

Introduction

In recent years, the integration of technology into education has led to a profound transformation, fundamentally reshaping the traditional learning landscape in unprecedented ways. This shift has been especially notable in response to significant challenges such as the global COVID-19 pandemic (Mhlanga & Moloi, 2020). As educational institutions worldwide grappled with sudden closures, the enforcement of social distancing measures, and the urgent need to transition to remote learning modalities, technology emerged as a vital resource, offering innovative solutions to ensure the uninterrupted continuity of teaching and learning processes. E-learning quickly emerged as a cornerstone of educational continuity, providing a flexible and accessible alternative to traditional classroom instruction, and empowering educators to deliver curriculum content remotely. Many advantages and benefits have been attributed to e-learning, including reducing educational disparities and creating a more inclusive learning environment by allowing the sharing of course materials regardless of geographic location (Maphalala and Adigun et al., 2021), improving student learning (Amutha, 2020), and enhancing access to education (Mhlanga and Moloi, 2020).

However, prevailing literature often favours ICT as the primary technology. Amutha (2020) highlights the wide range of communication devices and applications encompassed by ICT, including radio, television, cell phones, computers, network hardware and software, and video conferencing. Shava (2020) emphasizes the pivotal role of ICT in teaching and learning. Xulu (2024) focuses on ICT's use in learning African languages. Graham et al. (2020) examine the motivations behind South African

teachers' adoption of ICT, while Mhlanga & Moloi (2020) highlight the use of television, Zoom, Teams, and other ICT platforms in e-learning.

While ICT has undoubtedly provided numerous benefits to education, particularly in the context of COVID-19, its implementation often emphasizes technological features at the expense of addressing fundamental educational requirements (Nwosu, et al., 2023). In essence, the focus tends to lean towards delivering content rather than encouraging vital aspects such as student engagement, active learning, and knowledge retention. This discrepancy raises concerns about whether the utilization of technology aligns effectively with the genuine educational needs and goals of both students and educators. Moreover, the importance of student engagement in the learning process cannot be overstated. According to Torres Castellanos et al. (2023), the prevalence of apathy among teenagers and young adult scholars, particularly in developing countries, leading to high dropout rates, is closely associated with the passive nature of conventional classroom activities that fail to adequately engage them. Grewe and Gie (2023) noted a similar trend in South African higher education, emphasizing that student engagement reliably predicts academic success.

The Fourth Industrial Revolution (4IR) introduces numerous technologies capable of enhancing collaboration, creativity, and student engagement through immersive and interactive virtual environments such as the Metaverse, Holographic Technology, and Virtual/Augmented/Mixed Reality. Despite this potential, scholars have not extensively examined the transformative opportunities offered by these technologies in education, as there is limited scholarly work in this field, specifically in the context of developing countries such as South Africa.

As a result, this study aims to explore these emerging niche technologies, examining them through the lens of sustainable transition theories. These theories provide a framework for understanding how systems, such as the education system, transition from traditional approaches to more sustainable ones. Specifically, we utilize the Multi-Level Perspective Framework, which scrutinizes various levels: the regime (representing the current education system), the Landscape level (encompassing factors exerting pressure on the Regime, destabilizing and disrupting traditional teaching and learning modalities, while facilitating the adoption of specialized technologies), and the Niche level (where new disruptive technologies are being developed).

The paper follows this structure: Section 2 presents the theoretical framework from which the research questions emerge. Section 3 outlines the research methodology. Section 4 presents the findings, followed by the development of a conceptual framework.

2. Theoretical Framework

2.1 Sustainability Transitions

Various socio-technical systems (systems that serve societal functions such as energy, water and education) are faced with sustainability challenges due to climate change and resource depletion (Köhler et al., 2019). The Energy system for instance is confronted with carbon dioxide emissions issues leading to a need for a "just transition". The education system grapples with a persistent challenge regarding access, particularly in higher education, where there is insufficient capacity to accommodate the high volume of applicants due to resource constraints such as limited availability of teachers and infrastructure.

Sustainability transitions research aims to address these challenges, advocating for radical shifts rather than incremental changes from existing to new socio-technical systems as the solution (Köhler et al., 2019). Various theories explain socio-technical transitions, including the Multi-Level Perspective (MLP), Technological Innovation System approach (TIS), Strategic Niche Management (SNM), and Transition Management (TM). For this study, the Multi-Level Perspective is employed.

2.2 Multi-Level Perspective (MLP) Framework

The Multi-Level Perspective (MLP) Framework is employed in this study because it offers a structured approach for analyzing socio-technical transitions. (Geels, 2020). It suggests that transitions occur through dynamic processes across three analytical levels (Köhler et al., 2019) namely:

a) Regime Level: This level focuses on the established norms, regulations, and governing bodies shaping a socio-technical system (Ting & Rob Byrne, 2020). It is crucial to view this tier as a socio-technical system that requires examination involving its actors, components of existing technology, and the rules and regulations that govern it (Kanger & Schot, 2019).

b) Landscape level - These refer to external changes influencing the socio-technical environment, such as cultural norms, political frameworks, and macroeconomic shifts (Garcia et al., 2020; Ting & Rob Byrne, 2020). External developments apply pressure on the regime, leading to destabilization and facilitating the integration of niche technologies into the current system. Consequently, this creates a transition.

c) Niche - At this level, new technologies are being developed in experimental spaces (Garcia et al., 2020). Although these niche technologies are smaller in scale compared to those that dominate the regime, they have the potential to expand gradually, gather momentum, and eventually break into the socio-technical regime, particularly when external landscape developments exert pressure on the regime. Eventually, these innovations can spark broader transformative changes within the system, paving the way for a new socio-technical regime.

This study is concerned with the transition of the education system in South Africa. Therefore, informed by the MLP Framework, we ask the following:

Research Question 1	*The Regime level* – Who are the current actors and what are the technologies, and regulations within the existing education system regime?
Research Question 2	*The Landscape level* - Which landscape developments and external factors are applying pressure on the current education regime, contributing to its destabilization?
Research Question 3	*The Niche Level* - What technologies are present at the niche level, and what challenges do they face in diffusing into the mainstream?

3. Methodology

A non-systematic literature review was undertaken to explore the transition of the education system in South Africa. To gather comprehensive insights, data were sourced from reputable academic databases such as Google Scholar, SCOPUS, and Web of Science (WoS), chosen for their broad coverage of scholarly journals (Linnenluecke et al., 2020). Furthermore, newspapers were utilized to stay updated on the latest developments in the field of study. The literature review encompassed the years 2020 to 2024, selected to capture the most pertinent and current research in the field.

Primary search terms employed included "Education" AND ("Emerging technolog*" OR "Digital Technolog*" OR Metaverse OR "Virtual reality" OR "Augmented reality" OR "Mixed Reality" OR Hologra*) AND "South Africa", aiming to identify literature at the intersection of education and cutting-edge technologies in South Africa specifically. Through this approach, a comprehensive overview of the current landscape of educational technology was sought, encompassing both academic research and industry developments.

4. Results and Discussion

Research Question 1: *The Regime level* – *Who are the current actors and what are the technologies, and regulations within the existing education system regime?*

The South African education system involves various actors, regulations, and technologies working together to provide quality education and equip learners for future challenges.

Actors: Key actors in the Education system include schools (primary and secondary), universities (and other Higher Education institutions), teachers, students, communities, and government entities overseeing policy, funding, and oversight. Mhlanga and Moloi (2020) underscore that within South Africa, the educational framework is overseen by two national departments: the Department of Basic Education (DBE), which manages primary and secondary schooling, and the Department of Higher Education and Training (DHET), tasked with overseeing tertiary education and vocational training. These departments are further complemented by provincial education departments, which are entrusted with implementing national policies and addressing local educational matters (Mhlanga & Moloi, 2020).

Regulations: There are a range of policies in place to leverage Information Communication Technologies (ICT) to enhance various aspects of the sector including the National Plan for Higher Education, and the White Paper for Post-School Education and Training (Maphalala and Adigun, 2021).

Technology: Currently, there are various modalities employed in the South African education system. These are face-to-face, e-learning and hybrid (face-to-face and e-learning). Zooming in on the e-learning modality, several technologies are employed. From a scholarly perspective, the prevailing literature indicates that e-learning in South Africa exclusively relies on ICT as its technological framework. Technologies within this framework encompass ICT tools such as computers and tablets, E-Learning platforms including video conferencing and online resources, and administrative systems managing records and communication. Mhlanga and Moloi (2020) reported that the Department of Education utilized television and radio programming aimed at primary and secondary school students during COVID-19. At the tertiary level, Microsoft Teams, Zoom, WhatsApp, and similar tools were utilized (Mhlanga and Moloi, 2020; Mpungose, 2023). Furthermore, Maphalala and Adigun (2021) emphasized the adoption of Learning Management Systems (LMS) in Higher Education, providing a comprehensive online learning environment equipped with instructional tools for faculty-student interaction.

From the preceding discussion, it becomes apparent that the technologies associated with the 3rd Industrial Revolution are actively employed across all educational levels in South Africa, while those pertaining to the Fourth, remain largely unexplored.

Research Question 2: *The Landscape level* - *Which landscape developments and external factors are applying pressure on the current education regime, contributing to its destabilization?*

The emergence of COVID-19 has been the predominant catalyst for the widespread adoption of digital technologies globally, prompting a shift in the education sector towards e-learning modalities. However, additional factors are also reshaping the educational landscape, placing pressure on traditional face-to-face learning. One such factor is the growing demand for education, spanning primary, secondary, and tertiary levels. For instance, in the 2020 academic year, the University of Johannesburg received 200,000 applications for first-year students but could only accommodate 10,000 (SABCnews, 2020). Similarly, in 2024, Wits University reported receiving 140,000 applications for first-year students but could only accommodate 6,000 (Wits University, 2024). This highlights the need for e-learning to address the limitations of physical classroom space and meet the demand for education.

However, the e-learning modality is not without challenges. The literature frequently highlights student's lack of engagement and social interaction in online learning. Raphique (2023) asserts that

unlike physical classes, online learning lacks real-time face-to-face interaction, posing a greater challenge in fostering student engagement across different times and spaces.

These challenges further contribute to the destabilization of the current educational socio-technical regime and therefore create opportunities for niche technologies to gain prominence in the mainstream.

Research Question 3: *The Niche Level - What technologies are present at the niche level, and what challenges do they face in diffusing into the mainstream?*

Radical innovations such as the Metaverse, holographic technology, and virtual/augmented/mixed realities are gradually surfacing in the South African education system. The integration of these technologies into education has the potential to revolutionize learning, creating immersive and collaborative environments that enhance engagement, facilitate active learning, and boost retention of knowledge (De Felis, Thango, 2024, Grewe & Gie, 2023). In the next sections, the Metaverse and XR will be discussed.

The Metaverse

The Metaverse is a term that describes a shared online virtual space where users (through Avatars) can interact with a computer-generated virtual environment and other fellow users in real-time, while also enabling them to create and customize avatars. (De Felis et al., 2023; Thango, 2024).

It is used in several sectors including training medical professionals for surgical procedures in the health sector and holding virtual conferences in the finance sector (De Felis et al., 2023), even music concerts can be held in the metaverse.

In the education sector, Thango (2024) explored the use of the Metaverse for exam writing in the South African context, suggesting that this would simulate real-world scenarios where students can practice their skills in a safe environment.

Figure 1: A classroom in the Metaverse (www.blog.cryptostars.is)

He underscores the benefits of utilizing this technology to decrease exam writing costs and establish immersive environments that foster active learning. Other scholars (Lopez et al., 2023) stated that it promotes active participation from students, meaningful learning, digital competence, and communication skills.

As a technology at the niche level, the Metaverse shows potential in enhancing student engagement and preparing learners for the digital world. Successful integration hinges on addressing accessibility, equity, and collaboration between educators, policymakers, and technologists.

Virtual reality (VR) /Augmented Reality (AR) /Mixed Reality (MR)

While the Metaverse uses elements of VR, AR and MR (collectively known as XR), these two technologies are not the same. One of the major differences is that the Metaverse allows for interaction with the digital world and fellow users (through Avatars), while XR only allows interaction with the virtual world.

VR envelops the user in a fully artificial virtual environment, AR is a digital overlay over the real world, while MR integrates the two so that

interaction with both the digital world and the real world is possible. (Galisnka et al., 2023).

Figure 2: Augmented Reality in Healthcare
(alanizyoutims.blogspot.com)

Nonetheless, scholars have discovered that XR offers students immersive digital experiences, potentially revolutionizing classrooms by enhancing psychological presence, behavioral interactivity, and student engagement (Al Ansi et al., 2023). Galisnka et al. (2023) further assert that research suggests a correlation between learning effectiveness and the degree of immersion. Additionally, Oraba (2024) emphasizes the importance of student retention and effective learning within VR and AR environments.

In conclusion, within the niche level of the Multi-Level Perspective framework, XR technologies—comprising VR, AR, and MR—offer distinct capabilities. As it continues to evolve, its role in shaping future interactions between the digital and physical realms will be pivotal, along the entire value chain of the Education system.

Diffusion of the Metaverse and XR in Education socio-technical regime

The findings above clearly indicate the many benefits associated with using Niche technologies in the Education space. However, there are a number of challenges specifically in the South African context that hinder the diffusion of the Metaverse and XR in the education sector.

These include reliable and affordable internet access for all students, privacy and data security concerns, and the digital skills required to engage with the Metaverse for both students and teachers, as well as hardware and software requirements, specifically for students from low-income backgrounds (Oraba, 2024, Thango, 2024). Nwosu, et al (2023) emphasize the possible widening of the digital divide which might take place, especially in rural areas because of access to digital infrastructure and the internet. Their findings further indicate challenges associated with the change in school curriculum and policy, as well as a lack of digital culture. Grewe and Gie (2023) further note issues related to the students' use of the technology which may include nausea, addiction and reduced physical connection.

Overcoming these challenges requires a multi-faceted approach that addresses various aspects of infrastructure, policy, and education. These include digital infrastructure investment, digital skills training, efforts such as providing subsidies for hardware and software and Curriculum and Policy Adaptation, ensuring that policies support the adoption and implementation of these technologies. Once these can be overcome, these technologies that sit at the Niche level, have the potential to transform the current Education socio-technical regime into a new one, where students are highly engaged.

5. Conceptual Framework

Based on our findings, we developed a conceptual framework (refer to Figure 3) for transforming South Africa's education system.

At the regime level, the educational socio-technical system involves various stakeholders across the education spectrum, governed by regulatory bodies ensuring technology oversight, with ICT prevailing as the dominant technology.

On the Landscape level, external factors such as the COVID pandemic, increased educational demands leading to space limitations, and challenges with online student engagement and collaboration are exerting pressure on the existing regime. This pressure creates opportunities for technologies at the Niche level, such as the Metaverse, Holographic technologies, and XR, to potentially revolutionize learning by fostering immersive, collaborative environments conducive to engagement, active learning, and knowledge retention.

However, the diffusion of these niche technologies into the mainstream faces hurdles such as unequal internet access, privacy concerns, digital literacy gaps, and resource requirements, exacerbating the digital divide. Overcoming these challenges will pave the way for the transition of the education system, blending existing structures with niche technologies. This transition will incorporate technology

developers, updating regulations to integrate new technologies, and utilizing a mix of ICT, Metaverse, and XR.

The transformed education system promises improved student presence, interactivity, engagement, participation, learning quality, digital skills, and communication abilities.
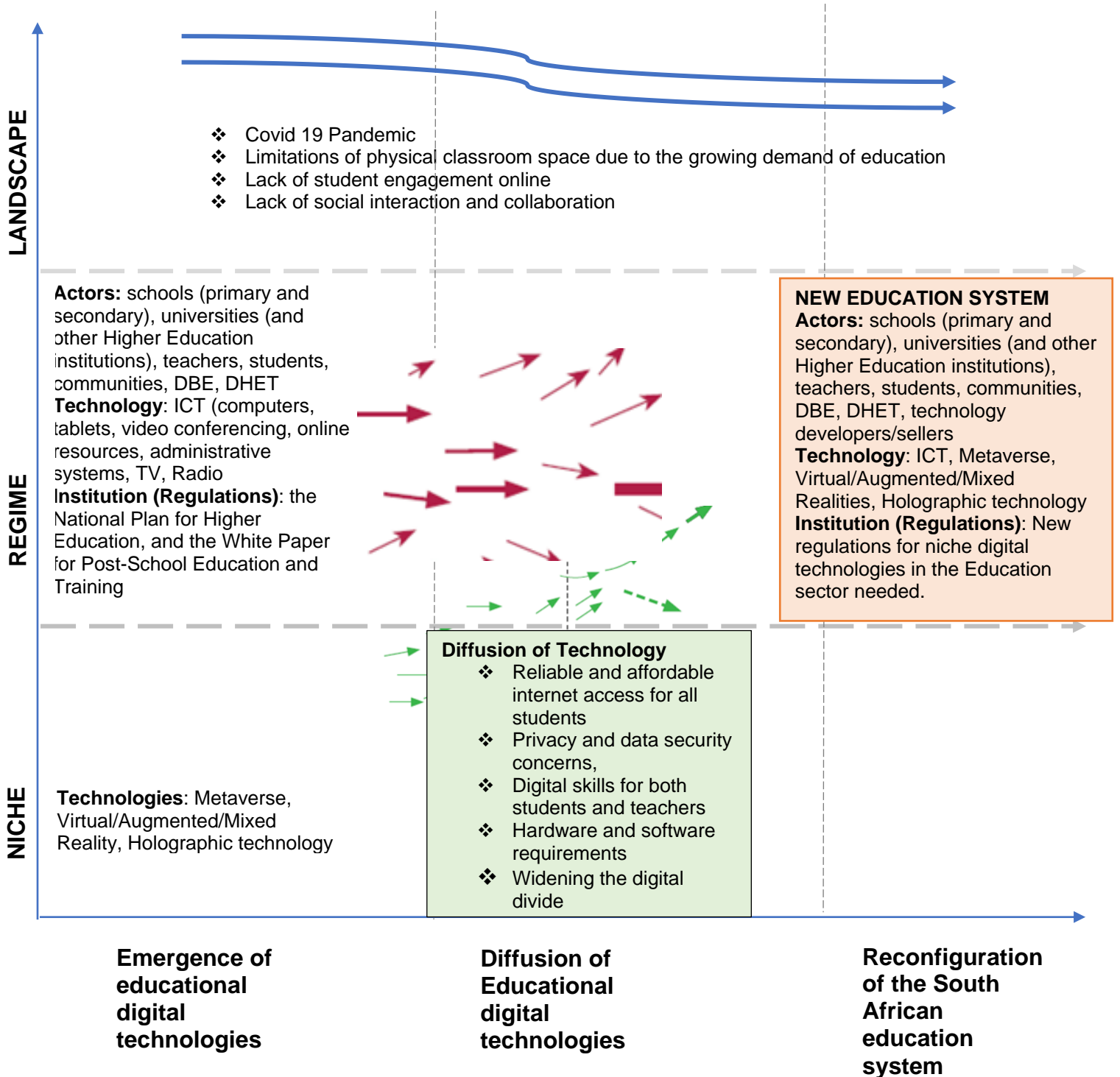
LANDSCAPE

- ❖ Covid 19 Pandemic
- ❖ Limitations of physical classroom space due to the growing demand of education
- ❖ Lack of student engagement online
- ❖ Lack of social interaction and collaboration

REGIME

Actors: schools (primary and secondary), universities (and other Higher Education institutions), teachers, students, communities, DBE, DHET
Technology: ICT (computers, tablets, video conferencing, online resources, administrative systems, TV, Radio
Institution (Regulations): the National Plan for Higher Education, and the White Paper for Post-School Education and Training

NEW EDUCATION SYSTEM
Actors: schools (primary and secondary), universities (and other Higher Education institutions), teachers, students, communities, DBE, DHET, technology developers/sellers
Technology: ICT, Metaverse, Virtual/Augmented/Mixed Realities, Holographic technology
Institution (Regulations): New regulations for niche digital technologies in the Education sector needed.

Diffusion of Technology
- ❖ Reliable and affordable internet access for all students
- ❖ Privacy and data security concerns,
- ❖ Digital skills for both students and teachers
- ❖ Hardware and software requirements
- ❖ Widening the digital divide

NICHE

Technologies: Metaverse, Virtual/Augmented/Mixed Reality, Holographic technology

Emergence of educational digital technologies

Diffusion of Educational digital technologies

Reconfiguration of the South African education system

Figure 3: Conceptual Framework for the transition of the Education socio-technical system in South Africa (Adapted from Geels and Schot (2007), Geels (2019), International Science Council (2019)

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