Journal of Education, 2024
Issue 97, http://journals.ukzn.ac.za/index.php/joe doi: http://dx.doi.org/10.17159/2520-9868/i97a01

Conceptualising a framework for digitally transforming teacher education in the South African context

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(Received: 10 June 2024; accepted: 4 October 2024)

Abstract

While the COVID-19 pandemic may have been subdued, online learning has come to stay not only because of its numerous advantages but because the digitised global trend continues to unravel. This necessitated a project aimed at understanding how a School of Education (SoE) in South Africa prepares future teachers for the digitised classroom. Since then, diverse aspects of the digital pedagogical practices in the Bachelor of Education programme have been investigated including the digital curricular readiness of the SoE, its e-textbook capabilities, and academics' and students' experiences of digital pedagogy. In this paper, we draw from these empirical findings to conceptualise a framework for shaping educational futures. We employ the Technological, Pedagogical, and Content Knowledge and Substitution, Augmentation, Modification, and Redefinition models to explain the requirements for the digital transformation of teacher education in South Africa. We used a qualitative case study research design to conceptualise an Active Digital Pedagogies framework that academics can employ to develop student teachers for the future workplace. The framework contributes access to quality education for all by guiding policy directions at classroom, institutional, and national higher education system levels.

Keywords: digital transformation, teacher education, 4IR classroom, TPACK, SAMR, active digital pedagogies framework

Introduction

In recent years, Digital Transformation (DT) has gained momentum in many traditional Higher Education Institutions (HEIs) on the back of the Coronavirus pandemic that necessitated a forced transition to online study modes (Arek-Bawa & Reddy, 2020). The

abrupt transition created opportunities for the academic community to stop using traditional pedagogical approaches/formats and embrace digital technologies in learning and teaching engagements. Nonetheless, Rodrigues indicated that "technologies are still weakly used in education and training" (2022, p. 1), probably because academics adopted the weak model of DT that simply facilitates knowledge transfer rather than the intensive model (Arek-Bawa & Reddy, 2023a; Area-Moreira et al., 2016).

The intensive model integrates various teaching approaches, digitally developed resources, online communication with research, and content created to engender meaningful learning in an interactive environment (Area-Moreira et al., 2016). This model aligns more with the competency-based curriculum allied with education 4.0 geared towards equipping pre-service teachers with Technological, Pedagogical, and Content Knowledge (TPACK) and other cross-functional skills needed to thrive in their digitized Fourth Industrial Revolution (4IR) workplace (Arek-Bawa & Reddy, 2022; Atibuni et al., 2022). Given that "technology can amplify great teaching, but great technology cannot replace poor teaching" (Organisation for Economic Co-operation and Development, 2015, p. 4), it is essential to have a reference frame to guide meaningful pedagogical engagement via digital technologies. Such a framework is deemed crucial in teacher education that is responsible for capacitating any nation's workforce with the requisite competence to contribute effectively to its growth (Maringe & Chiramba, 2022).

In 2022, we commenced a project to understand how the SoE produces future technically and pedagogically competent teachers for the 4IR classroom through the Bachelor of Education programme (B.Ed). The SoE offers core disciplinary content and teaching method modules in the four-year B.Ed programme to students mainly from quintiles 1 and 2 schools in predominantly poor and under-privileged communities (see Le Grange et al. 2020). Like many traditional institutions, the SoE transitioned abruptly to digital education at the start of the pandemic-imposed lockdown.

Since the commencement of the project, four empirical studies have emerged from it. The first paper (Arek-Bawa & Reddy, 2022) assessed *the digital curricular readiness* of the SoE after the COVID-19 pandemic struck. Our findings revealed that the digital B.Ed curriculum offered students mixed education experiences while indicating a likely epistemological limitation for some students resulting from the exacerbated digital divide in South Africa. The second paper (Arek-Bawa & Reddy, 2023a) on *e-textbook capabilities* in accounting education revealed that academics continually relied on print textbooks in their online pedagogical engagements. The third paper (Arek-Bawa & Reddy, 2023b) suggested that although academics are generally TPACK competent, their remote pedagogical practices may have been insufficient to enable students with the knowledge and skill set needed in the 4IR classroom. The fourth (Arek-Bawa & Reddy, 2024) study on students' experiences of DT revealed that their virtual learning experience is unlikely to prepare them for teaching in the digital age. These studies reveal a weak form of DT incapable of preparing students for their future digitised workplace.

Here, we aim to conceptualise a framework for the DT of the B.Ed curriculum that can assist academics to equip their students with TPACK and other cross-functional skills so that they can transfer such knowledge and skills to their workplace located in the 4IR. We employed a qualitative research design to synthesise a model for DT from a Macro-(National), Meso-(Institutional), and Micro-(Curriculum) level, drawing mainly from the project's empirical studies and related literature by answering this question: "How can the SoE equip pre-service teachers with the relevant digital, pedagogical content knowledge and other human skills in readiness for the 4IR classrooms?" We proceed from here with the research methodology, followed by the literature review section, and an explanation of theoretical underpinnings before offering a summary of the previous empirical studies. This is followed by a discussion, the model presentation, and a conclusion.

Research methodology

We employed an interpretive qualitative research design to conceptualise a framework for understanding DT in teacher education based on the case of the SoE. The case study approach is usually employed when one is seeking an in-depth understanding of a real problem or phenomenon (see Avery et al., 2011). While the case study approach is flawed for issues related to transferability or generalisation, it is deemed appropriate for offering knowledge about a specific complex situation as Bargate (2012) has reminded us. Thus, we employ the case study approach to gain in-depth insights "into the complex issue of teaching and learning in a digital environment" (Alhawsawi et al., 2023, p. 4), such as that of the SoE.

We employed a non-systematic review of related literature (see Kraus et al., 2022; Snyder, 2019) and prior empirical outputs from the larger project to attain the research objective. A non-systematic literature review "combines perspectives to create a new theoretical model" (Snyder, 2019, p. 334), hence our use of it in this paper. Like Alhawsawi et al. (2023), we interrogate "primary data in secondary sources to produce a substantive model for a contextually specific study on digital transformation" (p. 4). From the literature, we identified different elements of digital transformation that we considered in the proposed framework. Subsequently, we drew from other models such as TPACK (Koehler & Mishra, 2009), Substitution, Augmentation, Modification, and Redefinition (SAMR) (Puentedura, 2014), Institutional Reference Framework (García-Peñalvo, 2021), Active Training Model (Rodrigues, 2020) as well as from insights from previous empirical outputs from our project to conceptualise the framework specific to DT in SoEs.

Literature review

DT in HEIs

While some (Liu et al., 2011) consider DT as an application of information technology to organisational processes, others (Rodríguez-Abitia & Bribiesca-Correa, 2021) see it more as an evolutionary process from which information technology becomes a fundamental part of corporate and human existence. In line with the latter view, Morakanyane et al. (2017) conceptualised DT as "an evolutionary process that leverages digital capabilities and technologies to enable business models, operational processes, and customer experiences to

create value" (p. 437). Alenezi (2021) argued that in HEIs, DT requires a change in the institution's model guided by a strategic framework to develop innovative and effective approaches and practices to pursue its mission.

Extant literature also describes digital maturity as an entity's collected response to DT, indicating achievements in digitalising organisational processes, and developing its workforce's digital capabilities (Kittikumpanat, 2021). In other words, it portrays the ability of the institution to capitalise on the affordance of DT to enable its organisational processes and strategies (Rodríguez-Abitia & Bribiesca-Correa, 2021). Digital maturity indicates that the institution is in the DT journey. A digital maturity framework can be used at any phase of transformation to understand the maturity level of the institution by identifying the gaps that exist so that remedial action can be taken to close them and inform plans accordingly (Kittikumpanat, 2021).

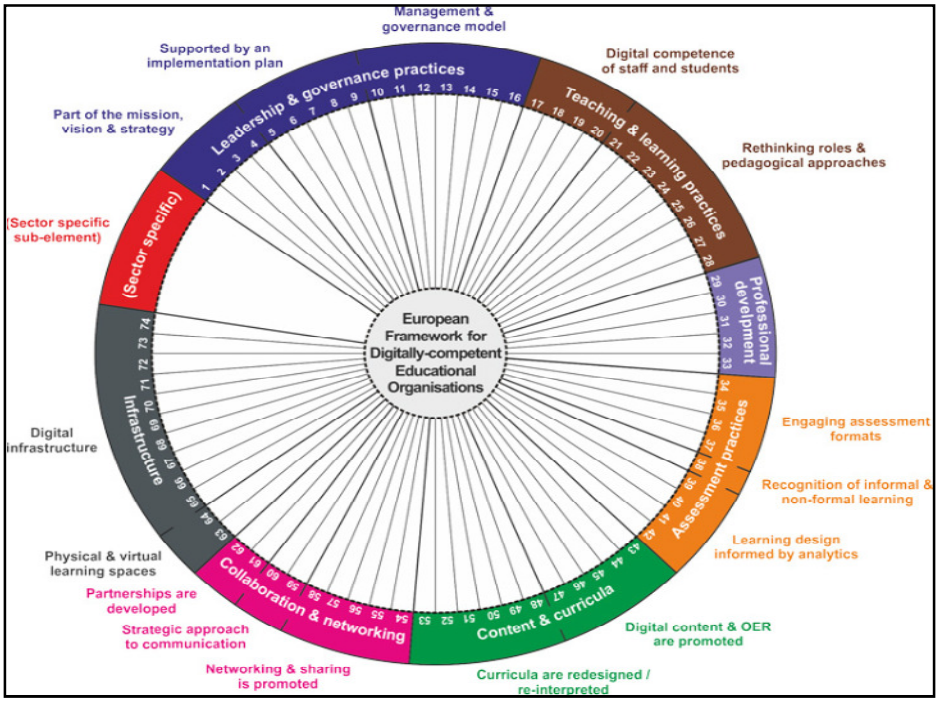
DT in education is driven mainly by the state and the respective institutions (Du toit & Verhoef, 2018; Waghid & Waghid, 2016). It facilitates effective e-learning, increases learning flexibility, and presents more data administration capabilities for instructional and academic improvements (García-Peñalvo, 2021). In addition, "the concept of time and space has been eliminated with digitalization" (Yildiz 2022, p. 189), and this has led to increased access to education for all, thereby bridging the epistemological gap between the haves and have-nots even among races in post-apartheid South Africa (Mhlanga, 2020). However, contextual challenges related to infrastructure, connectivity, electricity, funding, as well as unequal socioeconomic status (Mhlanga, 2020) associated with DT are rife in the developing world context that includes South Africa. Despite these challenges, the effective integration of digital technologies in university systems is imperative in achieving their primary mission of educating students to succeed in a complex and connected world (Alenezi, 2021; Kampylis et al., 2015). Scholars including García-Peñalvo (2021) and Rodríguez-Abitia and Bribiesca-Correa (2021) have emphasised the need for a reference framework to manage the transition to online learning, and to guide strategic decisions in the management of infrastructure and processes in addition to e-learning practices.

Over the years, a number of scholars (García-Peñalvo, 2021; Kampylis et al., 2015; Khalil et al., 2020; Kittikumpanat, 2021; Oliveira & de Souza, 2022; Rodríguez-Abitia & Bribiesca-Correa, 2021; Voronin et al., 2020) have devised different frameworks or models aimed at guiding/assessing DT maturity in HEIs. They have similar attributes, adapted with subtle differences to suit their peculiar needs. Below (Figure 1) the European DigCompOrg framework (Kampylis et al., 2015) is one such model that offers an extensive benchmark, comprised of nine elements and 74 sub-elements, for assessing the digital capacity of education institutions.

More recently, García-Peñalvo (2021) has defined a seven-layered Institutional Reference framework to guide e-learning in HEIs. The details of the Institutional Reference framework are similar to those of the DigCompOrg save for the latter's emphasis on ethics since it aims to support the ethical use of data in online environments and DigComOrg appears to be more comprehensive. Moreover, its elements are not too different from those considered significant

for assessing DT in teacher education, as Khalil et al., (2020) have indicated. These include Digital Competencies, Literacy, Infrastructure, Learning Environments, Tools and Technologies, Policy & Strategy, Training, Communication and Collaboration, and Attitude toward digitisation (Khalil et al., 2020).

Figure 1
DigCompOrg Framework for Educational Institutions by Kampilis et al., 2015



Since contextual factors contribute to successful DT programmes, we have adapted the DigCompOrg framework that allows for sector-specific attributes in this paper to understand the DT maturity of the SoE to inform policy directions and further quality education for the 4IR.

DT in teacher education

In recent years, DT in teacher education has attracted the interest of scholars in different countries mainly because of the COVID-19 pandemic, which catalysed a forced transition (Arek-Bawa & Reddy, 2020). Nonetheless, Khalil et al., (2020) and Voronin et al., (2020) have called for further research in the field given the importance of teacher education in any education system. Alhawsawi et al., (2023) conceptualised the effect of DT on teacher beliefs and practices during the pandemic. They concluded that technology and other personal factors influenced their beliefs and practices. They also developed a theoretical model drawing from TPACK (Koehler & Mishra, 2006), SAMR (Puentedura, 2009), and Constructive Alignment (Biggs, 1996) to understand the complexities of teacher beliefs and practice to support them in the DT environment. From a review of relevant literature, Yildiz (2022) questioned the digital competencies of academics and teacher candidates in Cyprus while highlighting tools to measure these. Yildiz emphasised the indisputable need to

prioritise understanding DT in teacher education, especially in the developing world, and called for further research because of its importance in ensuring quality education for the 4IR.

Based on the analysis of participants' theoretical experiences in digitalisation in Russia, Voronin et al., (2020) developed a three-staged framework for implementing DT in teacher education. They emphasised in particular DT in teacher education as being vital to modernising the education system. In Portugal, Rodrigues (2020) developed an active training model for integrating DT into teacher training. Integrating the model into the instructional process confirmed the possible development of virtual teaching approaches in addition to pedagogical and didactic knowledge. Khalil et al., (2020) assessed DT in Pakistani teacher education institutions to devise strategies to bridge the digital divide between teacher educators and prospective teachers. They identified "digital competencies, acceptability, digital infrastructure, utilization and access of digital tools and technologies" (p. 11) as the principal factors that affected digital education and directly impacted any institution's transformation. They advocated for training programmes and for digitizing the curriculum to promote DT, which is essential to teacher education for the 4IR.

In South Africa, extant literature indicates increased interest in DT research in teacher education since the COVID-19 pandemic. These include the integration of artificial intelligence in teaching (Tarisayi, 2024), pre-service teacher preparation (Arek-Bawa & Reddy, 2023b; 2024; Kroon & Gravett, 2023); critical studies on digitization and inequality (Dlamini, 2022; Hoosen, 2022); digital transformation of teaching and learning (Prozesky, 2022); the use of digital technologies in different disciplines (Phakathi & Moll, 2022; Makonye, 2022; Arek-Bawa & Reddy, 2020) among others. However, we found none focused specifically on designing a framework as intended in this paper. In teacher education, Kroon and Gravett (2023) developed a one-year framework for the Post Graduate Certificate in Education programme to help pre-service teachers know, feel, think, and act like novice teachers. The focus was on teacher knowledge and skills in a one-year post-graduate programme, and it did not consider the broader teaching environment and structures that make meaningful teaching with digital technology.

Many of the above studies devised a framework for assessing DT in their contexts. In South Africa, Mhlanga et al., (2022) referred to the DT framework by KPMG and Google in determining the DT in the country's HEIs amid the COVID-19 pandemic. The absence of a contextualised framework for DT in the South African education arena left a void in the literature that this research project intends to fill.

Theoretical framework

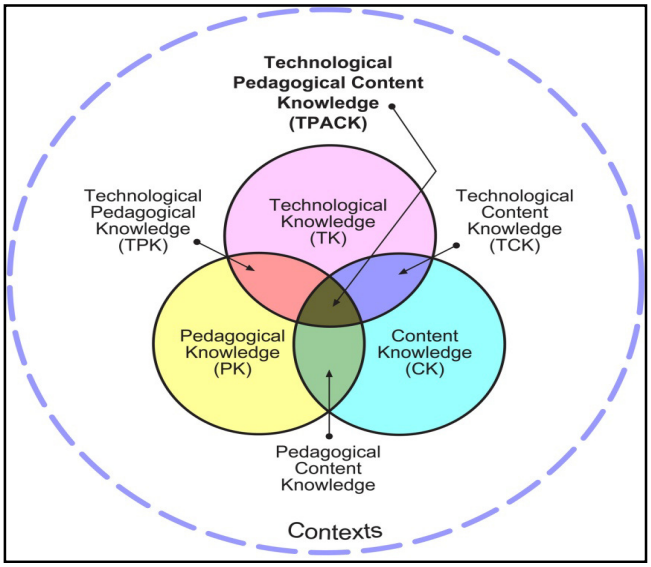
The project is framed by the TPACK Model, which is the dominant theoretical premise of the larger project in addition to the SAMR model.

Technological pedagogical and content knowledge (TPACK) model

The TPACK framework (Koehler & Mishra, 2009) is used widely in understanding and assessing effective teaching with technology. The individual knowledge domains that centre

on technology, pedagogy, and content, depicted in Figure 2, show the fundamental knowledge. These components are better regarded as interdependent components of a broader intricate knowledge configuration as illustrated by the intersecting rings (Koehler & Mishra, 2009).

Figure 2
The TPACK framework.



Source: Koehler & Mishra (2009, p.63)

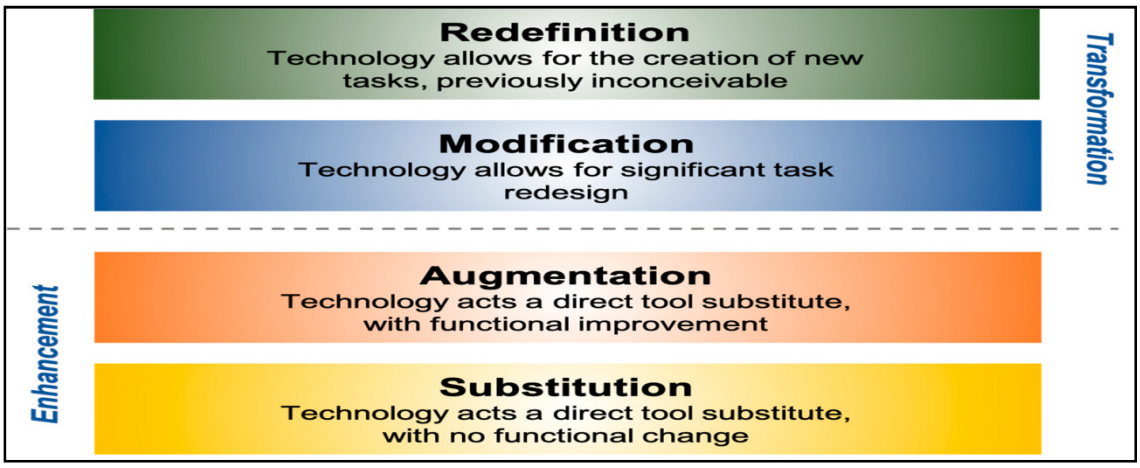
Content knowledge refers to traditional knowledge in any discipline and is considered a vital requirement in teaching (Mpungose, 2020). Pedagogical knowledge relates to "the cognitive knowledge for creating effective teaching and learning environments" (Guerriero, 2014, p. 5). Technological knowledge denotes the capability to engage technology efficiently in "information processing, communication, and problem-solving" (Koehler & Mishra 2009, p. 61). Pedagogical content knowledge "covers the core business of teaching, learning, curriculum, assessment, and reporting, such as the conditions that promote learning and the links among curriculum, assessment, and pedagogy [and]… the importance of forging connections among different content-based ideas" (Koehler & Mishra 2009, p. 64). We describe Technological Content Knowledge (TCK) as "an understanding of the manner in which technology and content influence and constrain one another," while knowing "how teaching and learning can change when particular technologies are used in particular ways" that is described as Technological Pedagogical Knowledge (TPK) (Koehler & Mishra 2009, p. 65). Finally, TPACK is "an understanding that emerges from interactions among content, pedagogy, and technology knowledge" (Koehler & Mishra, 2009 p. 66), culminating into meaningful dissemination of instruction with technology.

Although the TPACK framework may appear complex with a vague distinction between the individual constructs in theory, it is now "a required area of expertise for teachers" (Joo et al., 2018. p. 48) and is commonly considered in explaining teaching and learning in digital spaces. Thus, it formed the basis for assessing the digital pedagogical experiences of academics and students at the SoE as detailed in the data presentation section.

Substitution, Augmentation, Modification and Redefinition (SAMR) model

Another model that is extensively referred to (Alhawsawi et al., 2023; Alivi, 2019; Franco, 2019; García-Peñalvo, 2021) in integrating digital technology into teaching is Puentedura's (2014) SAMR model. Described as a tool that can assist educators in enhancing learning with technology, it consists of four classifications denoted by the letters of the abbreviation SAMR (Franco, 2019). As the name implies, at the *Substitution* level, technology is used as a direct substitute for the task with no functional change, such as reading an e-book instead of the paper version (Puentedura, 2014; Franco, 2019). At the *Augmentation level,* functional improvements are made, such as including a thesaurus in an e-book (Franco, 2019). The *Modification* level allows for the collaborative use of technology, significantly redesigning the activity and transforming learning (Puentedura, 2018). The *Redefinition* level makes possible creating new activities that were previously inconceivable without the use of technology as students take ownership of their learning (Puentedura, 2018). In the first two stages, students can use technology to enhance learning, while it is used to transform learning in the last two stages. While the model is critiqued for lack of detail because it was developed from experience and not research, it is very simple and easy to use (Franco, 2019).

Figure 3
SAMR model



Source: García-Peñalvo, (2021, p.3)

Although SAMR appears more focused on educational tasks to transform learning without reference to content or pedagogy individually, it addresses how technology can advance the two (Alivi, 2019). Alhawsawi et al. (2023) asserted that TPACK and SAMR offer a premise for explaining the crucial features that support the digital transformation of classroom teaching practices. Hence, we draw from the attributes of both models in conceptualising a framework for DT in the SoE. We capture a synopsis of the project's empirical studies in the following section.

Summary of the findings of the projects empirical studies

The table below reflects the research objective, methodology, findings, and main arguments of each empirical paper that emerged from the larger project.

Table 1
Summary of Empirical Studies

	Paper 1: Digital curricular transformation and Industrial Revolution 4.0 (4IR): Deepening divides or building bridges	**Paper 2: E-textbook Pedagogy in Teacher Education Beyond the COVID-19 Era**	**Paper 3: "Are we Producing Teachers for the 4IR Digitized Classroom?" – A Case Study of a School of Education**	**Paper 4: Preparing Pre-Service Teachers for Teaching in The Digital Age**
Research Objectives	1. "Ascertained how the B.Ed curriculum of the SoE has been digitally transformed to support the production of teachers prepared for the 4IR classroom." 2. "Whether or not the digital curriculum transformation of the B.Ed programme deepened the existing digital divide amongst students or built bridges for digital learning" (Arek-Bawa & Reddy, 2022, p. 308).	Explored how accounting academics adopted e-textbooks in their online pedagogical practice.	Assessed "academics' espoused TPACK competence in preparing future teachers for the digitized 4IR classrooms" (Arek-Bawa & Reddy, 2023b, p. 1).	"Explored pre-service teachers' experiences of digital teaching to determine the extent to which they felt prepared to teach in the digital age" (Arek-Bawa & Reddy, 2024, p. 19)
Research Methodology	Qualitative Study: Interpretive paradigm; case study design Content Analysis: curriculum templates and moderation reports.	Qualitative, interpretive paradigm; case study approach. Semi-structured questionnaire	Mixed-method QUAL + quan convergent parallel strategy; case study design; Questionnaires and individual interviews	Mixed-method QUAL + quan convergent parallel strategy; case study design; Questionnaires & FG interview

	Paper 1: Digital curricular transformation and Industrial Revolution 4.0 (4IR): Deepening divides or building bridges	**Paper 2: E-textbook Pedagogy in Teacher Education Beyond the COVID-19 Era**	**Paper 3: "Are we Producing Teachers for the 4IR Digitized Classroom?" – A Case Study of a School of Education**	**Paper 4: Preparing Pre-Service Teachers for Teaching in The Digital Age**
Findings	"The findings suggested varied learning experiences of content and digital skills for students who engaged with the digital B.Ed curriculum while pointing to a possible epistemological limitation for some students due to the contextual digital divide" (Arek-Bawa & Reddy, 2022, p. 308)	During the pandemic, academics "continued to depend on their print textbook due to preference, vision issues, limiting features of e-textbooks, and connectivity issues, among others" (Arek-Bawa & Reddy, 2023a, p. 194) Academics appreciated the affordance of e-textbook. Migrating influences include internet self-efficacy, cost & perceived usefulness.	1. "Academics are quite confident in their espoused TPACK competence" (Arek-Bawa & Reddy, 2023b, p. 11) 2. Academics used passive and interactive educational methods to prepare students for teaching in future. 3. "Academics were not confident in their students' ability to thrive in the classroom (Arek-Bawa & Reddy, 2023b, p. 10)	1 "Pre-service teachers were confident they had acquired the requisite TPACK and other cross-functional skills needed to teach in the digital age" (Arek-Bawa & Reddy, 2024, p. 18). 2. "The online pedagogical experience of pre-service teachers is unlikely to have enabled the skill set needed to thrive as teachers in the digital age" (Arek-Bawa & Reddy, 2024, p. 19).
Main Arguments	Argued for a curriculum review "that accommodates the contextual realities of the diverse student body to ensure a successful and sustainable digital curricula transformation beyond the pandemic era" (Arek-Bawa & Reddy, 2022, p. 323)	Argued for "a flexible, cost-effective approach to the migration to e-textbook pedagogy going forward" (Arek-Bawa & Reddy, 2023a. p. 194)	Argued that the reasons for academics' low confidence levels "are not unconnected with the epistemological gap emanating from the digital divide along socioeconomic lines" (Arek-Bawa & Reddy, 2023b, p. 12) since most students are from underprivileged backgrounds.	Argued for continued training in digital technologies for students as "digital pedagogies hold strong promises for increased access to quality education for all" (Arek-Bawa & Reddy, 2024, p. 19) much needed in this context of underprivileged backgrounds.

Discussion: Empirical studies

Over the past two years, the study reviewed different aspects of DT in the SoE, touching on the curriculum, education resources (from the perspective of Accounting Education), academics' experiences, and students' experiences (see Table 1). The curricular review of module templates concluded that the planned learning experience offered to "pre-service teachers varied in learning experiences, content, and digital skills" (Arek-Bawa & Reddy, 2022, p. 208). While some leaned toward a competency-based curriculum with a propensity to develop the skillset of their digitised 4IR classrooms, others tended towards a more passive performance-based curriculum. The latter incorporated more passive forms of engagement without intentionally creating opportunities for students to integrate technology actively in the virtual learning journey.

This outcome is likened to using technology as a tool at the substitution level of the SAMR model (Franco, 2019; Puentedura, 2014). Learning at this level depicts limited TPACK competence on the part of the academic who cannot design assessment tasks at higher levels of curriculum technology integration (Alivi, 2016). The review of moderation reports further revealed possible epistemological deficits by some students because of the digital divide along socioeconomic lines since they could not access the digitised curriculum. Limited engagement/interaction, low levels of digital literacy, unconducive home conditions, and electricity supply issues as well as assessment challenges and integrity, accounted for the epistemological gap. Hence, we call for revising the digitised curriculum to be more competency-based and respond to the contextual realities of the student body.

The review of e-textbook pedagogy confirmed technology engagement at the substitution level as academics substituted the print versions on digital learning platforms (Puentedura, 2014, 2018). They did not use "e-textbooks due to preference, vision issues, limiting features of e-textbooks, connectivity issues, etc." (Arek-Bawa & Reddy, 2024, p. 194). This indicates a weak DT model that facilitates knowledge transfer (Area-Moreira et al., 2016). However, they appreciated the affordance of e-textbook technology and identified internet self-efficacy, cost, and perceived usefulness as possible influences for migration. We argued for a flexible, cost-effective approach to the migration to e-textbook pedagogy going forward. We emphasised the development of Open Education Resource (OER) as follows (Arek-Bawa & Reddy, 2023a, p. 194):

> Academics can adapt, add, remove or rearrange e-textbook using the Open Education Resource (OER) model (Robert et al., 2021; Cox et al., 2021) advocated by the United Nations Educational Scientific and Cultural Organisations (UNESCO) in 2019 . . . OER are pedagogical materials made available in the public domain at no cost with the permission of the copyright owners to enhance equity and access to quality affordable education (United Nations Educational, Scientific and Cultural Organisation, 2021). These open resources have two major advantages to the academic community in the SoE. In the first place, the process of producing own e-textbooks allows for the incorporation of contextual indigenous knowledge thereby

> aiding the curriculum transformation/decolonization drive (Cox et al., 2021). In our learner-centred dispensation, this can be done in conjunction with students. For example, students can be asked to develop assessment activities with solutions (which are part of the pedagogical competencies) for inclusion in the e-textbook. The second advantage is that OER are usually open to everyone at minimal or no cost (Roberts et al., 2021; Cox et al., 2021). In an institution where majority of the students are from poor socio-economic background, the OER route appears to be viable option for the students.

Contrary to the outcomes of the first two papers, academics were confident in their self-assessed TPACK competence. They conceded to adopting passive pedagogical approaches allied with a performance-based curriculum (World Economic Forum 2020~~a~~; Du Preez & Le Grange, 2020; Khoza & Mpungose, 2020), especially when online teaching commenced. They, however, moved towards more active approaches since they appreciated the need for student interaction/engagement. Thus, their pedagogical practices may have enabled students to acquire the required teaching abilities, even if only partially. Nevertheless, academics were not sure that pre-service teachers developed pertinent knowledge/skills to thrive in the future. "Besides issues related to electricity/internet connectivity attested to by all participants**,** unchecked absenteeism/limited engagement, inability to ensure the credibility of assessments due to dishonesty, contract cheating and proctoring concerns hindered learning" (Arek-Bawa & Reddy, 2023b, p. 10). The use of passive teaching methods may indicate that academics were unable to design tasks that students would engage in a transformative manner, thus depicting lower levels of TPACK competence (Alivi, 2016) and learning at an enhancement level (Puentedura, 2014; 2018). DT was simply used to transfer knowledge (Area-Moreira et al., 2016). We argued further that issues about assessment dishonesty may have emanated from the knowledge deficit attributable to the digital divide and likely linked to socioeconomic conditions since most students are from underprivileged backgrounds.

In paper 4, we noted that most students believed they acquired the relevant knowledge and skills required of a teacher from their virtual education experience. Nevertheless, there were setbacks at the commencement of online education since no training was offered, and some had no experience with digital devices. While this may have "compelled them to devise strategies to solve their problems and learn independently . . . the findings also indicated the dominant use of passive instructional approaches allied to the performance -based curriculum" (Arek-Bawa & Reddy, 2024, p. 19), that is unlikely to promote the skills required of a teacher in the 21st-century classroom (Khoza & Mpungose, 2020; World Economic Forum, 2020a). Coupled with the limited interaction as well as poor-quality feedback, we concluded that it is unlikely that they "acquired the requisite TPACK and cross-functional skills to teach in the digital age" (Arek-Bawa & Reddy, 2024, p. 19). Passive pedagogical approaches and limited engagement also suggested using technology at substitution or augmentation SAMR levels that support non-transformational curriculum engagement and a weak form of DT (Area-Moreira et al., 2016; Puentedura, 2014; 2018). We further argued for continued training in digital pedagogies for the academic community since

it promises greater access to quality education for all, especially in this context where the majority are from previously disadvantaged backgrounds.

Synthesis of project outcomes

From the above synthesis of the published papers in the project, the golden thread in the B.Ed. programme appears to be a digital pedagogy that is more allied to the performance-based curricular stream than a competency-based one. The former, focused on direct instruction, facilitates passive learning and memorisation (Khoza & Mpungose, 2020; World Economic Forum, 2020). The latter is an interactive model that uses various approaches, "including online platforms, to promote collaborative learning in a communal space . . . tailored toward producing cross-functional skills" (Arek-Bawa & Reddy, 2022, p. 311) required now and in their future workplace (Chisholm, 2019; Khoza & Mpungose, 2020).

Even though there is a semblance of a competency-based curriculum, as seen in some module templates and as academics strove to engage their students, the odds were higher. Some curricular documents mirrored traditional approaches (paper 1); academics transferred their print resources into online platforms and did not exploit the affordance of the e-textbook pedagogy that could have engendered a transformative learning experience (paper 2). Further, academics struggled to engage and interact with students as they adopted predominantly passive teacher-centred approaches (papers 3 & 4). Poor quality feedback meant that students could not easily correct learning (paper 4). They all characterise a performance-based regime (World Economic Forum, 2020; Khoza & Mpungose, 2020) with limited curriculum technological transformation capacity and a weak model of DT (Area-Moreira et al., 2016; Puentedura, 2014, 2018).

Active digital pedagogical practices

Consequently, the issues are reduced to the level of interactivity embedded into the instructional process and the ability to attract or engender students' participation. Indeed, interactivity and the ability to engage students are the pillars of effective learning with technology (Bishop-Monroe et al., 2021; Jepson & Moulton, 2016). This view is supported by Puentedura's (2018) SAMR model, which is premised on student activities via technology. In a review of relevant literature on digital curriculum transformation, Jepson and Moulton (2016) identified critical indicators for the success of online programmes. They include retaining students by making the programme more participatory and engaging by using diverse digital technologies and pedagogical strategies to make it more relevant. Other indicators include using technology to improve the learning experience, ensuring quality programmes, and fostering a learning community that permits students to be independent yet interactive. In addition, Bishop-Monroe et al., (2021) suggested that academics must be trained in online pedagogical strategies because students' approach to learning is mainly determined by the academics' conduct of their educational activities.

Contextual considerations

Another issue that contributed to the project's outcomes is related to the contextual realities of students since most are from underprivileged homes. In paper 1, we pointed "to a possible epistemological limitation for some students who battle to engage the digitalised curriculum arising from a contextual digital divide" (Arek-Bawa & Reddy, 2022, p. 322). In paper 2, we argued that academics should develop e-textbooks, possibly with indigenous knowledge, using OER to aid the transformation of the curriculum while increasing access to quality education for all students. In paper 3, we suggested that the epistemological gap exacerbated by online learning likely had an impact on the learning experience of students from underprivileged backgrounds. And in paper 4, we argued for continued training in digital technologies for students since "digital pedagogies hold strong promises for increased access to quality education for all" (Arek-Bawa & Reddy, 2024, p. 19). This is much needed in this context in which most students are from previously disadvantaged backgrounds.

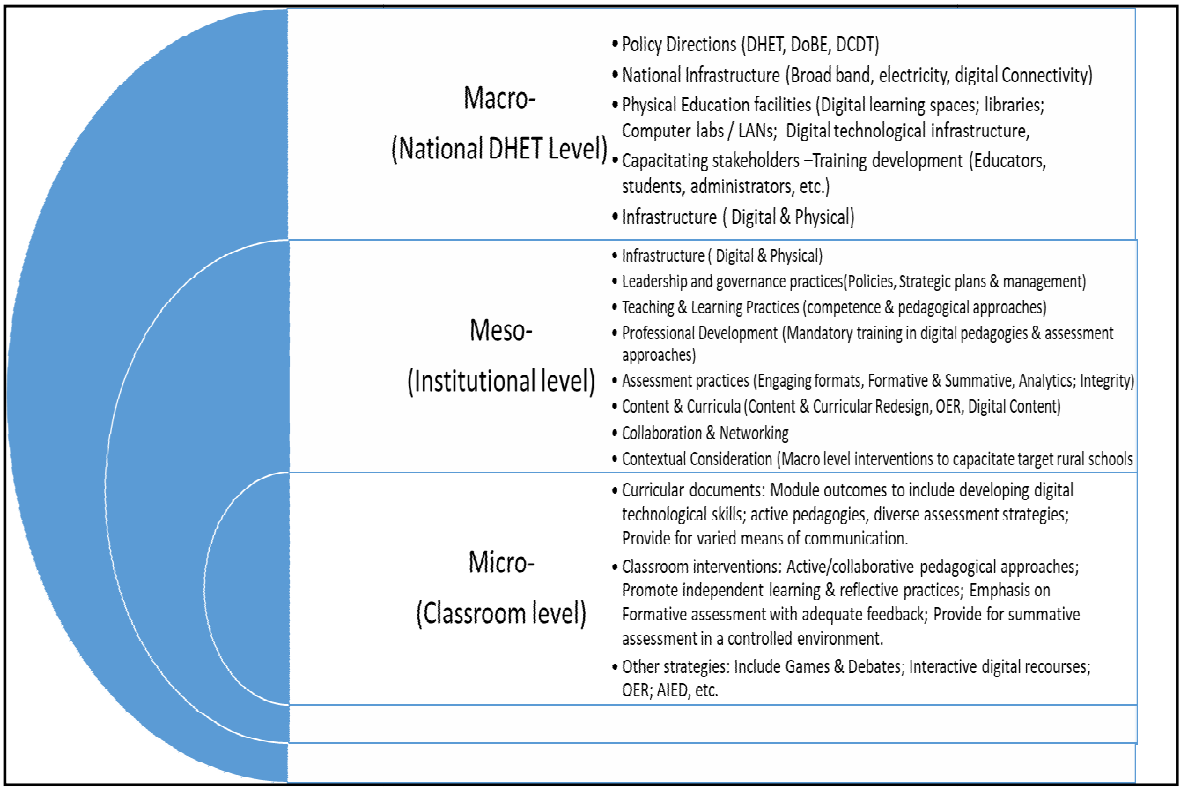
In addressing this problem, we join like-minded scholars (Timmis & Muhuro, 2019) by calling for a systemic intervention. As indicated earlier, DT is driven by the state and the institution (Du toit & Verhoef, 2018; Waghid & Waghid, 2016). Thus, we propose a three-pronged approach at Macro-, Meso- and Micro-levels (Haas & Hadjer, 2020) to DT that will assist academics in equipping student teachers with the relevant TPACK and other human skills in readiness for the 4IR classrooms.

Macro-, Meso- and Micro-contextual levels

At the Macro-level, the experiences and activities of academics are impacted by the laws of the land, the structures of the national HE system (the Department of Higher Education and Training (DHET), the Department of Basic Education (DBE) and the Ministry of Communication and digital technologies) in addition to other social environments including that of the labour market (Li et al., 2021). These state organs provide policy directions, fund HEIs and schools, and provide the broad infrastructural base that enables digital education. The Meso-level refers to the institutional context such as the university where the project is located (Haas & Hadjer, 2020; Li et al., 2021). Respective HEIs are responsible for creating an enabling environment for academics to facilitate digital education effectively (García-Peñalvo, 2021; Waghid & Waghid, 2016). The Micro-level addresses the individual context, which may vary from one academic to another (Li et al., 2021) even within the same institutional context. In this study, the Micro-level focuses on the context related to the enactment of virtual teaching and learning, i.e., academics' engagement with digital technologies to further meaningful learning. Understanding issues using these three combined layers is ideal when dealing with complex realities such as education (Boeren, 2019). Hence, in this project we conceptualise a framework for DT in the SoE from a Macro-, Meso-, and Micro-level perspective, as seen in Figure 4.

Proposed Framework for Active Digital Pedagogies

Figure 4
Active Digital Pedagogies Framework (Author generated)



At the Macro level, the South African government considers DT necessary and plans for a robust infrastructure in every corner of the country to capacitate society with the requisite skills to navigate the digital landscape (Department of Communications and Digital Technologies, September 2023). In addition to creating enabling policies for DT, the ADT advocates that the national plans accommodate the development and enhancement of physical education facilities such as digital learning spaces, computer labs, and other digital technological infrastructure. The organs of the state (DHET and DBE) must take responsibility for capacitating the school community to engage in digital pedagogies.

While the DBE is also committed to DT, a pilot study on the digital maturity of schools in South Africa concluded that "access to the internet by learners is very low at an average of 32%, . . . attributed to the lack of infrastructure that includes digital devices, dedicated facilities, and basic electricity" (Van Greunen et al., 2021, p. 6). The report further indicated a "lack of understanding of the benefits of using digital technologies as a tool in teaching and learning" (p. 8). Since the state is a key driver in DT, all organs of government must continue together to ensure that the transformation cuts across the entire country, as indicated by the DCDT (September 2023), including rural schools. As it is, the institution and other HEIs are much more digitally matured than the quintiles 1 and 2 schools from which the student population hails. As such, we echo the sentiments of Timmis & Muhuro (2019) that the institution must reach out to schools to support them in the digital transition of students to university. Where finances allow, the institution could contribute digital infrastructural

support. Old laptops could be donated to target schools. Workshops could be organised as part of outreach and community services to increase awareness of the affordance of DT, capacitate teachers, and develop digital literacy among learners.

Drawing from the DigComOrg framework, the institution, with the support of the DHET, provides the infrastructure and enabling environment at the Meso level. The institutional leadership and governance practices steer the implementation of DT across all facets of the university, supported by its strategic plans and policies. It covers curricular design, digital content and OER, teaching and learning practices, assessment practices, networking, and professional development. While the study did not directly interrogate the infrastructure and policies, respondents (staff and students) were relatively happy with the state of the institution's digital technological ecosystem, save for the issues related to the integrity of the assessments (see papers 1, 3, & 4) and delayed technical support (paper 4). The framework highlights the need for the institution to shore up its online assessment systems to maintain its integrity partly by installing proctoring software. In addition, there is a need to increase the number of ICS staff/contractors attending to technical issues to reduce the lead time involved in fixing broken devices.

A recurring finding from all four papers is the need for academic and student training. Mandatory professional development sessions in digital pedagogical and assessment practices should be an ongoing requirement for all academics to acquaint them with varied online assessment practices as well as interactive ways of engaging students and making lessons interesting. We suggest mandatory sessions because many believe they are TPACK competent (paper 3), especially after surviving the COVID academic era, even when operating at the enhancing SAMR level. A mandatory session improves their abilities and keeps them abreast of current pedagogical practices in the ever-evolving world of DT. Academics could also be given teaching relief to make room for them to develop OER, possibly with students' contribution.

Students also require training in digital technologies to navigate digital pedagogies. A robust strategy for developing students' digital skills should be designed in conjunction with students to enable a localised approach to navigating technologised spaces (Timmis & Muhuro, 2019). Any prior encounters with digital technologies, as suggested in the Macro phase, will be helpful or the institution can start at the entry point. The first-year orientation programme must include training in digital pedagogies that could also be offered monthly or quarterly for interested students. Technologically savvy student mentors can also be engaged in the academic support team to assist needy students.

At the Micro-level, we draw from the AT framework (Rodrigues, 2020, p.26–28) to guide classroom practices. AT begins with the curriculum of the respective disciplines. The Course outlines/module templates must be designed to incorporate outcomes that enable the acquisition of TPACK competence and other cross-functional skills.

- Module outcomes must include developing digital technological skills, which are currently lacking. That way, it becomes a compulsory requirement for academics to

meet to attain the module objectives, which will be further confirmed during moderation.
- Semester outlines/plans should include the topics, modes of delivery, and activities and the planned teaching approaches to execute each session. These should consist of active digital pedagogical practices that foster transformative learning.
- Planned assessment practices catering to diverse methods—peers, groups, projects, assignments, formal, informal, oral, practical, online, and face-to-face should be clearly described.
- Methods of communication should also be stated

Classroom interventions- Important AT strategies include:

- "Project work; problem-based learning; group research or peer work, including Internet research; discussion, with reflection and communication; and flipped classroom" (Rodrigues, 2020, p. 27). These collaborative approaches synchronously via breakout rooms promote learning at transformative levels if executed effectively (Puentedura, 2014). Furthermore, these interpersonal strategies foster healthy relationships as individuals interact and influence others in the diverse global setting (World Economic Forum, 2020).
- Independent learning via self-study, internet research, and case studies using real-life scenarios fosters learning autonomy, creativity, and problem-solving skills.
- Reflective practices on pedagogical work aid self-regulation and foster meta-cognitive and long-life learning abilities.
- Emphasis on formative assessments in a community of practice that allows students to improve what and how they learned promotes deeper cognitive engagement using "feedback, teacher and student regulation, self-regulation and self-assessment" practices (Rodrigues, 2020, p. 28). Nonetheless, adequate training in online assessment practices in a controlled online environment enhances the integrity of summative assessments.

Other Micro-level strategies include:

- Games and debates make learning fun and exciting, with a tendency to promote healthy competition among learners.
- Integration of interactive digital teaching resources would enhance learner engagement and learning.
- Integrate Artificial Intelligence in Education (AIED) tools to facilitate automated grading and feedback while enhancing assessment integrity, student understanding, and engagement (Al-Haimi et al., 2021).

If implemented meticulously, the Active Digital Pedagogies (ADP) framework promises to provide pre-service teachers with the skillset for the digital age. However, the Micro-level strategies are not cast in stone. The key is to engage students in the digital learning space as advocated by literature (Bishop-Monroe et al., 2021; Jepson & Moulton, 2016; Puentedura,

2018) during the instructional process. While resource limitations and other contextual challenges may sometimes hinder interactive classroom engagement, it remains the responsibility of the academic to further meaningful learning irrespective of the mode of education. Academics must exude transformative agency (Damşa et al., 2021) as they plan ingenious techniques for engaging students and improving attendance aimed at achieving desired objective amid the constraints and difficulties associated with digital education.

Conclusion

As the concluding section of a project aimed at assessing the digital transformation concerning the 4IR teacher education, in this paper we conceptualised the ADP framework as a reference guide to aid DT in teacher education. Having assessed the digitised curriculum, e-textbook pedagogy, as well as the experiences of students and academics on the digital education experiences, we conceptualised the three-layered Macro-, Meso- and Micro-level contextual framework to assist academics in preparing pre-service teachers for their future digitised classrooms. The three-pronged approach offers insight for addressing/implementing DT from the perspective of the national HE system via interventions at the school level and a Macro/Meso link requiring HEIs to support schools, especially those in their catchment area. That way, their interventions impact the individual students who become better prepared for tertiary education, indicating a Meso/Micro-interaction. Meso-level interventions emphasise continued training for the academic community to enhance Micro-level practices and classroom engagement. At the Micro-level, the framework advocates academics' use of active pedagogical practices in a virtual learning space that is otherwise blurred by the screen and dominated by passive approaches to learning. Without undermining the contextual challenges and limitations that academics encounter in their virtual platforms, we assert that pedagogy takes "primacy over technology" (Peimani & Kamalipour, 2021, p. 13). The need for academics to assume transformative agency to facilitate meaningful learning in the face of contextual challenges cannot be over-emphasised.

We, however, caution against certain limitations noted in the study. Being case-based, the empirical study draws from stakeholders' experiences in one teacher education institution and the findings may not be prone to generalisation. Nevertheless, a detailed description of the processes has been documented in line with the tenets of the interpretive paradigm to foster replicability. Interested scholars with adequate resources could expand the scope beyond the SoE to the entire university or include SoEs in other institutions at the state or national level to provide a more robust perspective. Also, the strategies for active pedagogical engagement at the Micro-level and institutional Meso-level or Macro interventions are in no way exhaustive. As a reference guide, the framework serves as a starting point for the meaningful implementation of DT and assessing digital maturity. Future researchers may also employ the framework to evaluate the digital maturing of HEIs, SoEs, and other educational institutions. In addition, it may be argued that the implementation of the ADP may be constrained by limited resources, especially in rural institutions. However, resource limitations are not peculiar to the ADP but are associated with the implementation of DT. As we have indicated earlier in this paper, DT is a journey, and each institution is at a different stage of maturity.

As a reference guide, the ADP offers valuable insights for implementing, navigating, and assessing DT in institutions of higher learning in the developing world context.

Further, by advocating for the development of OER with the capacity to incorporate indigenous contextual knowledge, the framework aids curriculum transformation/decolonisation. UNESCO endorses such resources as well as the integration of Artificial Intelligence in Education as tools for ensuring equitable access to quality education for all (Miao et al., 2021; United Nations Educational, Scientific and Cultural Organisation, 2021) sought after by all stakeholders in teacher education. Finally, the project contributes research capabilities to advance South Africa's national e-Strategy imperative and to the scholarship of DT and 4IR in the developing world context.

Acknowledgement

This work is based on the research supported wholly by the National Research Foundation of South Africa (Grant Number: 138467)

References

Alenezi, M. (2021). Deep dive into digital transformation in Higher Education Institutions. *Education Science*, *11*(770), 1–13. https://doi.org/10.3390/educsci11120770

Al-haimi, B., Hujainah, F., Nasir, D., & Alhroob, E. (2021). Higher Education Institutions with Artificial Intelligence: Roles, promises, and requirements. In A. Hamdan, A. E. Hassanien, R. Khamis, B. Alareeni, A. Razzaque & B. Awwad (Eds.), *Applications of Artificial Intelligence in business, education and healthcare: Studies in computational intelligence 954* (pp. 221–238). Springer. https://doi.org/10.1007/978-3-030-72080-3_13

Alhawsawi, S., Alhawsawi, H., & Sadeck, O. (2023). Conceptualizing the effects of digital transformation during Covid-19 on teachers' beliefs and practice. *Pedagogies: An International Journal*, *19*(1), 148–163. https://doi.org/10.1080/1554480X.2023.2188216

Avery, A., Cresswell, K., Crowe, S., Huby, G., Robertson, A., & Sheikh, A. (2011). The case study approach. *BMC Medical Research Methodology*, *11*(1), 100–108.

Alivi, J. S. (2019). A review of TPACK and SAMR models: How should language teachers adopt technology? *Journal of English for Academic and Specific Purposes*, *2*(2), 1–11. https://doi.org/10.18860/jeasp.v2i2.7944

Area-Moreira, M., Hernández-Rivero, V., & Sosa-Alonso, J. J. (2016). Models of educational integration of ICTs in the classroom. *Comunicar: Revista Científica de Comunicacíon y Educacíon*, *24*(47), 79–87. https://doi. org/10.3916/C47-2016-08

Arek-Bawa, O., & Reddy, S. (2020). Blending digital and technological skills with traditional commerce education knowledge in preparation for the 4IR classroom: The COVID 19 catalyst. In J. A. Smit, N. Mkhize, N. Ndimande-Hlongwa & L Ramrathan (Eds.), *Learner and subject at the dawn of digital research-led teaching and learning in the time of Covid-19* (pp. 144–166). CSSALL Publishers. https://doi.org/10.29086/978-0-9869936-5-7/2020/AASBS04

Arek-Bawa, O., & Reddy, S. (2022). Digital curricular transformation and Fourth Industrial Revolution 4.0 (4IR): Deepening divides or building bridges. *E-Journal of Humanities, Arts, Social Science*, *3*(11), 308–326. https://doi.org/10.38159/ehass.2022sp31124

Arek-Bawa, O., & Reddy, S. (2023a). E-textbook pedagogy in teacher education beyond the COVID-19 era. In U.G. Singh, C. S. Nair & S. Goncalves (Eds.), *Digital teaching, learning and assessment. The way forward* (pp. 179–198). Chandos Publishing. https://doi.org/10.1016/B978-0-323-95500-3.00002-X

Arek-Bawa, O., & Reddy, S. (2023b). "Are we producing teachers for the 4IR digitized classroom?"–A case study of a School of Education. *African Journal of Inter/Multidisciplinary Studies*, *5*(1), 1–14. https://doi.org/10.51415/ajims.v5i1.1197

Arek-Bawa, O., & Reddy, S. (2024). Preparing pre-service teachers for teaching in the digital age. *Athens Journal of Education 2024*, *11,* 1–23 | https://doi.org/10.30958/aje.X-Y-Z

Atibuni, D. Z., Manyiraho, D., & Nabitula, A. N. (2022). A Fourth Industrial Revolution paradigm shift in teacher education? *International Journal of African Higher Education*, *9*(2), 1–21. https://doi.org/10.6017/ijahe.v9i2.15365

Bargate, K. (2012). Criteria considered by accounting faculty when selecting and prescribing textbooks – A South African study. *International Journal of Humanities and Social Science*, *2*(7), 114–122. https://www.ijhssnet.com/journals/Vol_2_No_7_April_2012/12.pdf

Biggs, J. (1996). Assessing learning quality: Reconciling institutional, staff and educational demands. *Assessment & Evaluation in Higher Education*, *21*(1), 5–15. https://doi.org/10.1080/0260293960210101

Bishop-Monroe, R., Di Paolo Harrison, B. M., Knight, M. E., Corritore, C., York, A. S., & Rybarczyk, B. (2021). Preparing doctoral students to teach in an increasingly virtual world: A response to COVID-19 and beyond. *Online Learning*, *25*(1), 166–181. https://doi.org/10.24059/olj.v25i1.2446

Boeren, E. (2019). Understanding Sustainable Development Goal (SDG) 4 on "quality education" from micro, meso and macro perspectives. *International Review of Education*, *65*, 277–294. https://doi.org/10.1007/s11159-019-09772-7

Chisholm, Orin. (March 21, 2019). "Curriculum transformation: From didactic to competency-based programs in pharmaceutical medicine." *Frontiers in Pharmacology* 10. https://doi.org/10.3389/fphar.2019.00278

Cox, G., Willmers, M., & Masuku, B. (2021). Digital open textbooks for development. https://idl-bnc-idrc.dspacedirect.org/server/api/core/bitstreams/f31d198f-3a7f-4d66-8920-c35e0936a3f5/content

Damşa, C., Langford, M., Uehara, D., & Scherer, R. (2021). Teachers' agency and online education in times of crisis. *Computers in Human Behavior*, *121*, 1–16. https://doi.org/10.1016/j.chb.2021.106793

Dlamini, R. S. (2022). Complex inequalities and inequities in education: Expanding socially just teaching and learning through digitalisation in South Africa. *Alternation*, *39*, 193 – 213. https://doi.org/10.29086/2519-5476/2022/sp39a9

Du Preez, P., & Le Grange, L. (2020). The COVID-19 Pandemic, online teaching/learning, the digital divide and epistemological access. In L. Ramrathan, N. Ndimande-Hlongwa, N. Mkhize & J. A. Smit (Eds.), *Re-thinking the Humanities curriculum in the time of COVID-19* (pp. 90–106). CSSALL PUBLISHERS. https://doi.org/10.29086/978-0-9869936-1-9/2020/AASBS01

Du Toit, J. & Verhoef, A. H. (2018). Embodied digital technology and transformation in higher education. *Transformation in Higher Education*, *3*(1), 1–8. https://doi.org/10.4102/the. v3i0.52

Franco, M. (2019). SAMR and technology integration. *Technology and the Curriculum: Summer 2019*. Pressbooks. https://techandcurr2019.pressbooks.com/chapter/samr-and-technology-integration/

García-Peñalvo, F. J. (2023). Avoiding the dark side of digital transformation in teaching. An institutional reference framework for eLearning in higher education. *Sustainability*, *13*(4). https://doi.org/10.3390/su13042023

Guerriero, S. (2014). Teachers' pedagogical knowledge and the teaching profession. *Teaching and Teacher Education*, *2*(1), 7. https://www. Guerriero%2C+S.+(2014)

Haas, C., & Hadjar, A. (2020). Students' trajectories through higher education: A review of quantitative research. *Higher Education*, *79*(6), 1099–1118. https://doi.org/10.1007/s10734-019-00458-5

Hoosen, N (2022). The praxis of critical digital pedagogic practices in initial teacher education. In J. P. Makonye & N. S. Ndlovu (Eds.), *Innovations in online teaching and learning: Case studies of teacher educators from South Africa during the COVID-19 era* (pp. 43–64). AOSIS Scholarly Books. https://doi.org/10.4102/aosis.2022.BK376.03.

Jepson, J. & Moulton, D. (2016). Proudly pragmatic: Steps to online curriculum transformation. In S. Barker, S. Dawson, A. Pardo & C. Colvin (Eds.), *Show me the learning. Proceedings ASCILITE 2016* Adelaide (pp. 283–293). https://doi.org/10.14742/apubs.2016.814

Joo, Y. J., Park, S., & Lim, E. (2018). Factors influencing preservice teachers' intention to use technology: TPACK, teacher self-efficacy, and technology acceptance model. *Journal of Educational Technology & Society*, *21*(3), 48–59. http://www.jstor.org/stable/26458506

Kampylis, P., Punie, Y., & Devine, J. (2015). *Promoting effective digital-age learning-A European framework for digitally-competent educational organisations* (No. JRC98209). Joint Research Centre (Seville site).

Khalil, A., Ishaq, N. & Boedihartono, A. (2020). Digital transformation of teacher education by bridging digital divide between teacher educators and prospective teachers. *Journal of Contemporary Teacher Education*, *4*: 1–20. https://doi.org/10.58444/jcte.v4i.208

Khoza, S. B., & Mpungose, C. B. (2020). Digitalised curriculum to the rescue of a higher education institution. *African Identities*, *20*(4), 310–330. https://doi.org/10.1080/14725843.2020.1815517

Kittikumpanat, M. (2021). A conceptualized model of digital transformation for sport organization in Thailand. *Turkish Journal of Computer and Mathematics Education*, *12*(8), 2270–2276.

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60–70. https://www.learntechlib.org/primary/p/29544/.

Kraus, S., Breier, M., Lim, W. M., Dabić, M., Kumar, S., Kanbach, D., Mukherjee, D., Corvello, V., Piñeiro-Chousa, J., Liguori, E. and Palacios-Marqués, D. (2022). Literature reviews as independent studies: Guidelines for academic practice. *Review of Managerial Science*, *16*(8), 2577–2595. https://doi.org/10.1007/s11846-022-00588-8

Kroon, R., & S. Gravett. (2023). A framework for initial teacher education in an uncertain and fast-changing world. In S. Gravett & N. Petersen (Eds.), *Future-Proofing teacher education* (pp. 3–16). Routledge.

Le Grange, L. L., Du Preez, P., Ramrathan, L. & Blignaut, S. (2020). Decolonising the university curriculum or decolonial-washing? A multiple case study. *Journal of Education*, (*80*), 25–48. http://dx.doi.org/10.17159/2520-9868/i80a02

Li, X., Haupt, J., & Lee, J. (2021). Student mobility choices in transnational education: Impact of macro-, meso-and micro-level factors. *Journal of Higher Education Policy and Management*, *43*(6), 639–653. https://doi.org/10.1080/1360080X.2021.1905496

Liu, D. Y., Chen, S. W., & Chou, T. C. (2011). Resource fit in digital transformation: Lessons learned from the CBC Bank global e-banking project. *Management Decision*, *49*(10),1728–1742.

Makonye, J. P. (2022). 'Mathematics teacher educators' use of virtual tools in lecture delivery. In J. P. Makonye & N.S. Ndlovu (Eds.), *Innovations in online teaching and learning: Case studies of teacher educators from South Africa during the COVID-19 era* (pp. 157–173). AOSIS Scholarly Books. https://www.researchgate.net/publication/368863350_Mathematics_teacher_educators'_use_of_virtual_tools_in_lecture_delivery

Maringe, F., & Chiramba, O. (2022). The emerging discourse of the 4IR: Theoretical and conceptual overview in the context of teacher education in South Africa. In F. Maringe & O. Chiramba (Eds.), *The 4IR and teacher education in South Africa: Contemporary discourses and empirical evidence* (pp. 1–13). AOSIS Scholarly Books. https://library.oapen.org/bitstream/id/451e779e-bc60-4628-a368-9b02cf7c894b/BK306_Web%20PDF.pdf

Mashologu, Mlindi. (2023, September 6). *Communications and digital technologies on digital government workshop* [Address]. The Digital Government Workshop, Johannesburg, South Africa. https://www.gov.za/news/speeches/communications-and-digital-technologies-digital-government-workshop-06-sep-2023

Mhlanga, D. (2020). Industry 4.0: The challenges associated with the digital transformation of education in South Africa. In O. Aydin (Ed.), *The impacts of digital transformation* (pp.12–25.) Efe Academy.

Mhlanga, D., Denhere, V., & Moloi, T. (2022). COVID-19 and the key digital transformation lessons for higher education institutions in South Africa. *Education Sciences*, *12*(7), 464. https://doi.org/10.3390/ educsci12070464

Miao, F., Holmes, W., Huang, R., & Zhang, H. (2021). *AI and education: A guidance for policymakers*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000376709

Morakanyane, R., Grace, A. A., & O'Reilly, P. (2017). Conceptualizing digital transformation in business organizations: A systematic review of literature. In BLED 2017 Proceedings (pp. 427–443). http://aisel.aisnet.org/bled2017/21

Motsabi, S., Diale, B. M., & Van Zyl, A. (2020). The role of social support in the persistence of first-year first-generation African students in a higher education institution in South Africa. *South African Journal of Higher Education*, *34*(4), 189–210. https://doi.org/10.20853/34-4-3486

Mpungose, C. B. (2020). Student teachers' knowledge in the era of the Fourth Industrial Revolution. *Education and Information Technologies*, *25*(6), 5149–5165. https://doi.org/10.1007/s10639-020-10212-5

Oliveira, K. K. D. S., de Souza, R. A. (2022). Digital transformation towards education 4.0. *Informatics in Education*, *21*(2), 283–309. https://doi.org/10.15388/infedu.2022.13

Peimani, N., & Kamalipour, H. (2021). Online education and the COVID-19 outbreak: A case study of online teaching during lockdown. *Education Sciences*, *11*(2), 72. https:// doi.org/10.3390/educsci11020072

Phakathi, N., & Moll, I. (2022). The affordances of iPads for learners, teachers and teacher educators in the documentation of visible learning and teaching. In J. P. Makonye & N.S. Ndlovu (Eds.), *Innovations in online teaching and learning: Case studies of teacher educators from South Africa during the COVID-19 era* (pp. 97–118). AOSIS Scholarly Books. https://doi.org/10.4102/aosis.2022.BK376.06.

Prozesky, M. (2022) The many voices of the 'digital turn': Four lines of inquiry into education and the digital in post-COVID-19 South Africa. In J. P. Makonye & N.S. Ndlovu (Eds.), *Innovations in online teaching and learning: Case studies of teacher educators from South Africa during the COVID-19 era* (pp. 285–299). AOSIS Scholarly Books. https://doi.org/10.4102/aosis.2022.BK376.17.

Puentedura, R. (2014). *SAMR: An Applied Introduction.* [PDF file]. Retrieved May 24, 2024, from https://www.Puentedura%2C+R.+(2014).+SAMR%3A+An+Applied+Introducti on.

Puentedura, R. (2018, November 15). *Applying the SAMR Model* [Video]. Common Sense Media. https://www.commonsense.org/education/videos/ruben-puentedura-on-applying-the-samr-model

Roberts, K., Benson, A., & Mills, J. (2021). E-textbook technology: Are instructors using it and what is the impact on student learning? *Journal of Research in Innovative Teaching & Learning*, *14*(3), 329–344. https://doi.org/10.1108/JRIT-04-2021-0028

Rodrigues, A. L. (2020). Digital technologies integration in teacher education: The active teacher training model. *Journal of e-Learning and Knowledge Society*, *16*(3), 24–33. https://doi.org/10.20368/1971-8829/1135273

Rodrigues, A. L. (2022). Integrating digital technologies in accounting pre-service teacher education: A case study in Portugal. *International Journal of Technology and Human Interaction*, *18*(1), 1–19. https://doi.org/10.4018/IJTHI.293200

Rodríguez-Abitia, G., & Bribiesca-Correa, G. (2021). Assessing digital transformation in universities. *Future Internet*, *13*(2), 52. https:// doi.org/10.3390/fi13020052

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, *104*, 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Students, computers and learning: Making the connection. (2015, September 15). [Report] PISA. Organisation for Economic Co-operation and Development Publishing. http://dx.doi.org/10.1787/9789264239555-en

Tarisayi, K. (2024). Preparing for AI's transformational potential: Rethinking teacher education In South Africa. *International Education Trend Issues*, *2*(1), 31–40. https://doi.org/10.56442/ieti.v2i1.364

Timmis, S., & Muhuro, P. (2019). De-coding or de-colonising the technocratic university? Rural students' digital transitions to South African higher education. *Learning, Media and Technology*, *44*(3), 252–266. https://doi.org/10.1080/17439884.2019.1623250

United Nations Educational, Scientific and Cultural Organisation, (2021). Briefing paper accessible open education resource. https://www.unesco.org/en/communication-information/open-solutions/open educational-resources.

Van Greunen, D., Kativu, K., Veldsman, A. & Botha, J. (2021): Enhancing ICT readiness of schools in South Africa. https://www.dst.gov.za/images/Policy_Brief_June_2021.pdf

Voronin, D. M., Saienko, V. G., & Tolchieva, H. V. (2020, May). Digital transformation of pedagogical education at the university. In *International Scientific Conference "Digitalization of Education: History, Trends and Prospects" (DETP 2020)* (pp. 757–763). Atlantis Press. 10.2991/assehr.k.200509.135

Waghid, Z., & Waghid, F. (2016). Examining digital technology for (higher) education through action research and critical discourse analysis. *South African Journal of Higher Education*, *30*(1), 265–284. http://dx.doi.org/10.20853/30-1-562

World Economic Forum. (2020). Schools of the future: Defining new models of education for the Fourth Industrial Revolution. https://www.weforum.org/reports/schools-of-the-future-defining-new-models-of education-for-the-fourth-industrial-revolution/

Yildiz, E. P. (2022). Teacher education in the digital transformation process in North Cyprus: A situation analysis study. *International Education Studies*, *15*(1), 187–219. https://doi.org/10.5539/ies.v15n1p187