International Journal of Education and Development using Information and Communication Technology (IJEDICT), 2024, Vol. 20, pp. 21-39

Exploring the impact of TPACK on Education 5.0 during the times of COVID-19: a case of Zimbabwean universities

Rekai Zenda
University of the Witwatersrand, South Africa

Dumisani Rumbidzai Muzira
Africa University, Zimbabwe

Mudadirwa Mujuru
Catholic University, Zimbabwe

ABSTRACT

The development of ICTs that can be used for Education 5.0 is rapid. Current educational practice suggests that many lecturers experience challenges in implementing the use of some form of ICT in teaching and learning. The research explores the impact of TPACK on the implementation of Education 5.0 in universities during the time of the COVID-19 pandemic in Zimbabwe. The qualitative research study was conducted with university lecturers. Data were collected through semi-structured interviews. Mishra & Koehler's (2006) TPACK framework which focuses on technological knowledge, pedagogical knowledge, and content knowledge was used as the lens of the study. During the COVID-19 pandemic, online delivery of education was found to be effective, convenient, and facilitated access to information. However, the universities experienced poor Internet connectivity, lack of infrastructure, unreliable devices and unavailability of software, as challenges to effectively implement Education 5.0. The training of lecturers to empower them to engage students effectively during the implementation of Education 5.0 was vital.

Keywords: *COVID-19; Education 5.0; ICT; TPACK; universities; Zimbabwe*

INTRODUCTION

Global trends have shown a sharp rise in the use of information and communication technologies (ICTs) because of the world-wide move to a knowledge-based society (Mandoga *et al.*, 2013). Thus, Higher Education Institutions (HEIs) are key to imparting necessary knowledge and undertaking research and community service (Leal Filho *et al.*, 2018; Togo & Gandidzanwa 2021). Education 5.0 is premised on the five pillars of teaching, research, community service, innovation and industrialisation (Keche 2021). The sudden and drastic introduction of this innovative education policy in higher and tertiary education institutions aims to create a competitive, industrialised and modernised society. To facilitate the achievement of this goal, innovation hubs have been set up in various universities across Zimbabwe (Togo & Gandidzanwa 2021). However, it is baffling that Education 5.0 came barely five years after the introduction of the Science, Technology, Engineering and Mathematics (STEM) policy in 2015, which targeted achieving the United Nations Sustainable Developmental Goals (Chitate 2016). According to Keche (2021) the abrupt introduction of Education 5.0 in Zimbabwean universities unmasked the gross inadequacies of the requisite ICTs and of the lack of competent ICT agents.

For the current study, the following research question was asked:

What is the impact of TPACK on the implementation of Education 5.0 in Zimbabwean universities during the COVID-19 pandemic?

ICT integration in universities during COVID-19

The demand for ICTs in universities increased during the outbreak of COVID-19 which demanded online teaching and learning. The COVID-19 pandemic exposed the unpreparedness of the colleges and higher education institutions to integrate ICT (Keche 2021). The World Health Organization preventive protocols for COVID-19 which were put in place resulted in universities' conventional face-to-face learning and teaching methods being substituted with online teaching and learning methods (Keche 2021). The unplanned, abrupt and drastic shift from face-to-face to total virtual teaching and learning, exposed universities' unpreparedness to fully embrace ICTs. ICT competency has been identified as a necessary pedagogical tool, particularly in universities, because ICTs significantly heightened the social, technological and psychological development of students (Victoria 2011). Furthermore, ICT use promoted collaborative, cooperative and creative learning and gave students greater chances of being independent and innovative. It increased contact among learners and facilitated the level of communication between these students and their lecturers and provided opportunities for departments, faculties, colleges and universities to communicate relatively easily.

ICT integration policy in Zimbabwe

The use of ICT in Zimbabwean universities must be understood in the context of the Millennium Development Goals that were set by the United Nations in year 2000. These goals highlighted the importance of ICT in the global development agenda (Pondiwa 2021). Thus, the national ICT policy that was adopted in Zimbabwe in 2005 makes significant references to the promotion of ICTs and pedagogical use in universities (Isaacs 2007, Musarurwa 2011). The policy's objectives are to promote the development of ICT infrastructure and to establish relevant structures and institutional mechanisms to promote ICTs, as well as to encourage equitable access of ICTs across gender, youths and people with disabilities (Isaacs 2007).

It follows that other policy frameworks governing the deployment and use of ICT in universities in Zimbabwe include the Presidential Commission of Inquiry into Education and Training (CIET) of 1999, the Draft ICT Policy on Education of 2016, and the Zimbabwe National Policy for e-Government of 2016 (MoPSE 2016c). The Education Ministry's draft ICT policy of 2001 addressed issues relating to equipping teachers with ICT competencies, provision of requisite infrastructure (ICT facilities) and to make ICT integration a success (Ministry of Education 2001, p. 17).

Despite these actions, the ICT Readiness Index placed Zimbabwe in the bottom 10 countries in the world (Kabweza 2011; Mandoga *et al* 2013). Thus, the use of ICT in teaching and learning is in its infant stage in Zimbabwe due to a lack of e-learning support (Chitanana *et al* 2008; Tsvuura *et al* 2021). Unlike well-resourced countries where governments fully assist universities, Zimbabwean universities have relied on donor funding to assist students and lecturers (Schleicher, 2020). Despite government policies, it is still apparent that most universities have not yet effectively adapted and integrated ICTs in teaching and learning. Research demonstrates that in the absence of clear-cut policies for ICT integration, there is danger of inconsistences in the way ICTs are embedded in various teaching and learning contexts and the quality of teaching and learning may be negatively impacted (Kangara, Gocha, Tsokota & Marovah 2022). Thus, Zimbabwe is one of the countries experiencing delays in the implementation of ICT-related policies due to lack of committed resources and concrete government plans to spearhead this.

The context of ICT integration in Zimbabwean universities

The COVID-19 pandemic increased the demand for use of ICT in universities to facilitate online teaching and learning during lockdowns (Mbunge *et al* 2020). The introduction of blended learning in most Zimbabwean universities helped to expose lecturers and students to the new normal of using ICT in both virtual and physical classrooms (Chitanana et al 2008). As a way of encouraging the use of ICT in education, most lecturers encouraged students to submit their assignments online, integrated ICT as a learning resource and students explored innovative ways of learning (Musarurwa 2011). This was a departure from the traditional way of hand written assignments which would be collected physically (Mandina 2015).

However, with the increased demand for use of ICT during the COVID-19 pandemic, the lecturers experienced heavy teaching loads and lack of e-learning support in terms of infrastructure when integrating ICT into teaching. The free online teaching platforms, such as Google Classroom and Zoom, presented ICT integration challenges in teaching and learning because of the limit on numbers they could accommodate and time limits (Majola 2020). Thus, examination processes, programmes and students' progression were the worst affected by the COVID-19 disruption. As a result, WhatsApp audio recordings were a preferred way to reach out to students because as was shown in earlier studies, it was affordable for both students and lecturers and compatible with most gadgets available to them (Musarurwa 2011).

However, the research indicates that in this context, students were either technophiles or digital natives (Lubega & Paul 2014), and thus, not all students would be comfortable using ICTs. The earlier studies indicated that some students did not have laptops or smart phones that were compatible with online teaching and learning platforms such as Google Classroom, Moodle, Teams or Zoom (Richard & Haya 2009). Furthermore, the students experienced Internet connectivity issues that included expensive data bundles and universities had limited Wi-Fi connectivity. All these factors had unmasked the slow ICT integration in universities, and even though they were convinced that ICTs could transform the education system, it was acknowledged that they should be integrated effectively (Ezumah 2020).

Education 5.0

Education 5.0 is premised on the five interrelated pillars of teaching, research, community service, innovation and industrialisation (Keche 2021). The proponents of Education 5.0 envisage the policy as key to the realisation of the industrialisation objective (Togo & Gandidzanwa 2021). Furthermore, the new policy is focused on addressing skills, knowledge and values and promoting learner-centred pedagogy through a system of specified critical outcomes, such as teamwork, critical thinking skills and problem-solving skills (Sayed & Ahmed 2011). Education 5.0 is an attempt to match the curriculum to culture and to the country's developmental needs, transforming the education system into an action-centred system that shapes future technology through innovation and industrialisation using the local environment in teaching and learning. As a heritage-based philosophy, it supports the application of gained knowledge from the local environment to produce relevant goods and services (Muzira & Bondai 2021), and developing higher-order learning skills, such as problem-solving, creativity, communication, digital literacy and citizenship, which are critical in society and requires lecturers to be skilful, creative, independent and self-directed (Binkley *et al* 2012; Dede 2010; Voogt *et al* 2013).

In this context, ICTs are widely considered to be a crucial input factor for industrialisation and development and in transforming the teaching environment into learner-centredness (Majola, 2020). Evidence reveals that ICT improves student motivation, understanding and promotes active collaboration and lifelong learning (Ezumah 2020). However, Chitate (2016) argued that skilled lecturers are fundamental for the industrialisation of a country.

THEORETICAL FRAMEWORK

Technological pedagogical and content knowledge (TPACK)

TPACK is the complex interaction between technology, pedagogy and content (Chai *et al* 2013). The TPACK framework explains the set of knowledge that lecturers need to teach students subject content using ICT. Thus, technological knowledge (TK) refers to the lecturer's knowledge of ICT, pedagogical knowledge (PK) is the lecturer's learning management ability, and content knowledge (CK) is subject matter knowledge (Malik *et al* 2018)**.** The interaction of these three basic forms of knowledge give rise to pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and TPACK (Cheng 2017; Nadolny *et al* 2017; Lin *et al* 2013).

Ideally, TPACK is multifaceted, integrative and transformative (Angeli & Valanides 2009; Koehler & Mishra 2009); promotes teaching to become linked to technology to allow students to take a non-linear learning path (Utomo *et al.*, 2017): develop self and learning innovations for lecturers to improve teaching and learning and provide support and equal opportunities for students (Pamuk *et al.*, 2015): contributes to the co-development of pedagogy and technology (Archambault & Barnett 2010): and requires lecturers to be willing to integrate technology into their teaching practices (Howell 2012).

The TPACK framework adds ICT to PCK and emphasises the connections, interactions and constraints that teachers encounter (Mishra & Koehler, 2006), and assesses lecturers' knowledge of technology integration with Education 5.0, which has been shown to impact their behavioural intention to use new technology (Lim & Harwati, 2021; Zhou *et al* 2020; Koh *et al* 2013). Investigating the interrelations of lecturers' Education 5.0 -TPACK knowledge provides valuable information about how to develop their ability to design pedagogical use for Education 5.0. A well-designed educational environment based on the Education 5.0-TPACK framework help lecturers to integrate ICT to promote creativity for the lifelong benefit of students.

Furthermore, TPACK is used to describe lecturers' capability to facilitate learning from certain content through a pedagogical approach and technology in the context of Education 5.0. Ideally, lecturers have content-specific knowledge about the subject they are teaching, and pedagogical knowledge about how to teach, including specific teaching methods (Shulman 1986), and TPACK significantly and positively influence their behavioural intention to use technology (Lim & Harwati 2021). They usually possess good PCK from teaching experiences and must transform their PCK into TPACK that is in line with Education 5.0 (Jiang *et al* 2021). Acquiring and developing these forms of knowledge are the foundation for Education 5.0-TPACK for lecturers to integrate technology into their teaching and learning processes. The three kinds of knowledge (TK, PK and CK) are seen to impact positively on lecturers' intention to implement Education 5.0. Thus, the TPACK model begins with the importance of lecturers' professional identity in relation to Education 5.0 knowledge and content knowledge.

Presumably, Education 5.0**-**TPACK changes the way students review, reflect and create by offering effective personal environments. Ideally, ICT can be transformative, effective, and task-oriented, create personal learning spaces, shift control to the learners, extend formal learning to more informal learning, and promote learner autonomy and participation (Botha & Herselman 2015; Jimoyiannis & Angelaina, 2011), and equip students with a range of skills and techniques, which develops their confidence in their capacity to learn and perform better (Mandoga *et al* 2013).

Essentially, Education 5.0-TPACK is necessary to change content organisation, instructional design, pedagogical philosophy, students' learning activities, and to shift lecturer's role from instruction to learning (Jimoyiannis 2010). Accordingly, there is a drastic paradigm shift from the classical classroom-bound, lecturer-centred approach to a more dynamic, interactive and

investigative approach. Thus, decentralised, connected and evolving learning communities allow students to shape their own learning ability (Galley *et al* 2014; Siemens 2005), leading to a progressive transformation of learner-centred, interactive and inquiry-based Education 5.0 (Tarling & Ng'ambi 2016).

In addition, it has been noted that ICT integration into the curriculum promotes critical thought, longer information retention and assumption of responsibility (Chai *et al* 2013; Totten *et al* 1991), and provides new solutions that trigger a range of new developments, boost competitiveness, and supports growth (Shoemaker *et al* 2012). Moreover, critical thinking is invaluable in Education 5.0 because it prepares students for employment challenges and civic duty, and equips them with new skills for successful economic and social engagement (Saavedra & Opfer 2013). The TPACK framework guides lecturers to integrate ICT into content and pedagogy to help them learn more effectively (Mishra & Koehler 2009), facilitates interaction and widens access to content and services (Sangrã 2001), and students can actively manipulate information and data to support divergent knowledge expressions rather than information recall (Howland *et al* 2013).

Education 5.0-TPACK has been found to aid student learning (Harris & Hofer, 2011), facilitate application of knowledge to transform the curriculum (Angeli & Valanides 2009), and help in understanding students' difficulties in learning the subject matter, seek ICT representations, and to adopt appropriate constructivist-oriented pedagogy (Akkoç, 2011; Wu *et al* 2008). The TPACK framework offers the following: enhanced opportunities for developing social groups and networks; supporting distributed cognition and collective intelligence and creating autonomous communities of learning (Jimoyiannis *et al* 2013); it also enhances collaborative online learning engagement, and sustains task orientation and advanced knowledge construction (Fong & Slotta, 2018; Totten *et al.*, 1991), and promotes learning ecologies where members work together and support each other (Tsiotakis & Jimoyiannis 2014); provides a virtual environment (Harasim *et al* 1995) and facilitates the use of a learner-centred approach to Education 5.0 (Hwee *et al* 2016).

Ideally, TPACK is associated with knowledge creation within an educational system that allows teachers to use technology to design project-based learning and prepare students for the future working model (Tee & Lee, 2011). TPK emphasises bringing in authentic problems through technological representation and engaging students with ICT as cognitive tools (Chai *et al* 2013). Partnerships for 21st Century Skills (2009) argued that students need proactive research skills, knowledge and professional conduct in industry to provide solutions to the ever-evolving economic challenges. Rather, TPACK changes lecturers' pedagogical cultures and philosophies by using appropriate ICT tools with students (Chai *et al* 2013; Doering *et al* 2014; Levin & Schrum 2013). Chai *et al* (2010) emphasised building lecturers' TPACK from pedagogical knowledge and explaining how ICT can enhance meaningful learning.

Therefore, building lecturers' learning design capacity is the most important factor for the successful integration and sustainability of ICT (Davis *et al* 2009; Hennessy *et al* 2007). Education 5.0-TPACK supports ICT integration in practice by allowing lecturers to focus on the connections among technology, content and pedagogy in real instructional-learning contexts. The TPACK framework was used to identify solutions for developing a content-based technological environment that addresses the Education 5.0 challenges. In this context, the TPACK framework creates feasible solutions focused on crafting a content-based technological environment that adequately addresses the challenges that come with the delivery of Education 5.0 (Koehler & Mishra 2009).

METHODOLOGY

This was a qualitative interpretive study with 12 lecturers at two selected Zimbabwean universities. The participants were selected using purposive sampling. We chose the selected

universities based on the assumption that we could learn best from the committed, successful implementation of technology for Education 5.0. The participating lecturers were selected because they were accessible, and were using face-to-face teaching methods and then had to transition to online learning because of the COVID-19 pandemic.

Online interviews were used to collect qualitative data for the study to explore lecturer's use of and familiarity with technology. We used WhatsApp to conduct the online interviews with lecturers because it was affordable. The individual semi-structured interviews lasted 20 minutes and were recorded for direct transcription to ensure trustworthiness - transferability, dependability, confirmability and credibility (Mpungose 2020).

The two universities were chosen because they represented use of a range of common technology initiatives and were willing to share their insights through research. Additionally, they represented a range of years of ICT implementation. After recruiting university lecturers as participants through an electronic flyer, the participants signed consent forms containing the details of the ethical procedures (confidentiality and anonymity). We generated a set of interview questions based on the ideas of the Education 5.0 and TPACK framework (Mishra & Koehler 2006).

We used thematic analysis to analyse the data. The interview data were first recorded and coded. Open coding was used to connect codes to categories. The transcriptions of the interviews were reviewed for recurring themes. The emerging themes were recorded within each category and identified supporting evidence for the results. The themes and categories that reflected the technology used by the participating lecturers in student learning were aggregated.

FINDINGS

Why is it important for lecturers implementing Education 5.0 to have knowledge and skills in ICT?

The lecturers indicated that technology has revolutionised teaching, research, community engagement, innovation and industry. One of the goals of Education 5.0 is to shape future technology in order to make innovation and industrialisation the product. ICT knowledge and skills create more versatile and effective learning environments. TPACK has been assessed as necessary to change content organisation, instructional design and pedagogical philosophy, students' learning activities, and to shift lecturer's role from instruction to learning (Jimoyiannis 2010).

Among the views expressed, Lecturer 12 indicated that staff development is important for the effective implementation of Education 5.0. He stated that,

> "*Teachers who are key in implementing Education 5.0 are expected to be more knowledgeable in ICT to meet student expectations*".

The participants indicated that they needed ICT skills to deliver information to the students. In this regard, TPACK is the main pillar in developing self and learning innovations for lecturers to improve teaching and learning and research has shown that it provides support and equal opportunities for students and make universities relevant (Pamuk *et al* 2015). One lecturer commented that knowledge and skills will help them use ICT in the class because

> *"…we use Moodle as a learning platform. Therefore, training in the form of refresher courses at the beginning of each semester is vital".*

In Education 5.0 it is imperative that lecturers attend regular in-service training, seminars, workshops and industrial site visits so they can appreciate the practical side of the knowledge acquired. Almas & Krumsvik (2008) argued that lecturers' technological skills influence the enacted TPACK in the implementation of Education 5.0, and one lecturer pointed out that.

> *"…lecturers need to be continuously trained in the use of technology in pedagogical activities in the classroom".*

Furthermore, Lecturer 9 said,

> *"The University offers training occasionally on pedagogical activities in the classroom though more frequent training is needed".*

In this regard, three of the lecturers referred to training as capacity development.

In relation to development and support, Lecturer 4 said,

> *"I attended capacity development course organised by universities and Zimbabwe Council for Higher Education [ZIMCHE] using webinars to develop us on research and how to use Moodle".*

Three other lecturers noted the following in agreement:

> *"I am eager to enhance my research skills by learning every new technology that comes my way, thus averting technophobia."*

> *"Training on Education 5.0 equips lecturers on data management and technology usage. Technology enhance collaboration, communication, problem-solving and critical thinking skills during their teaching."*

> *"Workshops help lecturers to acquire ICT skills. Visiting other institutions doing well in the use of technologies would help a lot."*

The lecturers recommended prioritising ICT pedagogic training in all universities. They concurred that exposing lecturers to more ICT workshops will help them use Moodle and Google Classroom effectively to engage students when teaching Education 5.0.

Lecturer 6 noted that,

> *"Knowledge of ICTs is paramount in electronic enhanced teaching and learning platforms".*

While another lecturer supported this view, stating that

> *"…since all learning programmes are now going digital, there is need to equip lecturers with ICT skills to stay abreast with these trends in education. However, the major challenge is lack of adequate funds".*

How does technology assist or help to improve teaching and learning of Education 5.0?

The lecturers felt that they are still behind in terms of technology use, and in using modern robots and simulations to enhance learning remains a pipe dream for them. Research has shown that TPACK enhances collaborative online learning engagement; sustains task orientation and advanced knowledge construction (Fong & Slotta 2018). Lecturer 1 noted the following about ICT:

> *"Due to the COVID-19 pandemic, digitalised knowledge and skills in ICT are a must. Unfortunately, ICT-competent lecturers in universities are still scarce".*

Technology also enhances lesson flow, and as argued by Harris & Hofer (2011), TPACK helps with planning daily lessons when choosing learning outcomes, the pedagogical enhancing activity and suitable ICT tools to benefit students.

Lecturer 2 concurred that,

> *"…technology can affect lesson flow; for example, poor network and infrastructure, unreliable devices and software can be a challenge".*

Further, Lecturer 10 stated that

> *"…technology is cost and time-effective and enhances participation".*

Many of the lecturers agreed that Education 5.0 is techno-oriented, in support of the views of Utomo *et al* (2017) who argued that TPACK promotes teaching using technology to allow students to take a non-linear learning path.

One lecturer explained that,

> *"ICT is an enabler for alternative teaching and learning modes. It also provides access to e-resources and promotes remote teaching and learning".*

While another lecturer noted that,

> *"ICT assists teachers to meet the global requirement. It helps teachers to prepare their teaching and provide feedback".*

ICT is now a necessity in universities for teaching, learning and information dissemination more so during COVID-19 lockdowns. However, for ICT to be used for these tasks, lecturers must be trained and competent. Training was perceived by the lecturers as important channel for improving their skills and stimulate actual contexts that include TCK, TPK and TPACK.

For example, Lecturer 3 stated that,

> *"…many lecturers cannot deliver lessons online due to lack of ICT training. Sometimes we fail to teach due to lack of Wi-Fi".*

Other lecturers commented that they were disappointed at their inability to exploit the full potential of ICT owing to the limitation as an individual and insufficient direct assistance from their universities in terms of TCK, TPK and TPACK.

Which methods of instruction do you think are essential in the implementation of Education 5.0 in universities during COVID-19?

According to the lecturers, the COVID-19 pandemic dramatically changed the mode of learning in universities because blended learning mostly replaced face-to-face learning. Ideal methods of instruction for the effective implementation of Education 5.0 include Moodle, Zoom, Google Classroom, Microsoft Teams and video conferencing. Collaborative learning facilitates the transformation of knowledge, sharpens interpersonal skills, and improves cognitive functions, meta-cognitive knowledge and academic success (Fong & Slotta 2018); however, it requires knowledge about implementing ICT into teaching and learning.

Two lecturers explained how they used collaborative learning during the COVID-19 pandemic, as follows:

> *"Under COVID-19, I use[d] Zoom, WhatsApp, Google Classroom, Microsoft Teams and university leaning management systems. However, students often complain of having no data, forcing lecturers to resort to using WhatsApp."*

> *"I am now using the Moodle learning platform, WhatsApp, emails and phone calls to reach out to my students during COVID-19, which has proven to be most effective and convenient."*

The lecturers prefer virtual teaching and learning because it allows them to upload documents, use YouTube videos, record lecture videos, and create online discussion forums, According to Mandoga *et al* (2013) TPACK equips students with a range of skills and techniques which develops their confidence in their capacity to learn and perform better. However, the lack of adequate ICT resources, including lack of lecturers remains a major challenge in the current period. As noted by Lecturer 8

> *"Virtual teaching and learning activities are smarter, more engaging, enhancing interactivity and students exploring vast bodies of knowledge faster, but my students did not have access to devices to help them with the online schooling."*

However, Lecturer 4 pointed out that,

> *"…the major challenge is getting students to embrace the various available teaching and learning technologies. Students prefer lectures through WhatsApp. Maybe, it is because it is more affordable and easier to use than using Zoom and other meeting platforms".*

The lecturers found flipped blended methods ideal for Education 5.0 because they can, for example, use WhatsApp and infuse it with formal platforms like Moodle, while having minimal physical contact with students and encouraging group and individual work. Project-based methods, which involves students doing practical activities, are considered to promote the smooth implementation of Education 5.0, and Tee & Lee (2011) argued that TPACK is a form of knowledge creation within an educational system that allow teachers to use technology to design project-based learning and prepare the student for the future working model. For instance, three lecturers commented,

> *"I use research as part of continuous learning. The students work in groups which encourages community engagement and I present lessons using PowerPoint"*,

while two other lecturers commented as follows:

> *"I teach my students using the project-based method".*

> *"ICT help to promote equality and inclusion, but it is about my ability to design and sustain high-quality teaching in digital environments."*

DISCUSSION

Lecturers' ICT knowledge and skills

Evidently, ICT knowledge and skills helps to create more versatile and effective learning environments. Thus, lecturers with ICT knowledge and skills, could practically implement Education 5.0 beyond their classrooms. Almas & Krumsvik (2008) argued that lecturers' technological skills influence the enacted TPACK in the implementation of Education 5.0 and shapes students' practice and perceptions. However, limited knowledge to integrate ICT fully in teaching were identified as the key factors affecting uptake of ICTs to teach Education 5.0. It emerged that ICT workshops and visits to other institutions greatly enhanced lecturers'

acquisition of ICT skills. Getting involved in workshops and prioritising ICT pedagogic training gave lecturers the opportunity to learn how to use modern teaching and learning platforms such as Moodle and Google Classroom. These platforms empowered lecturers to engage students effectively during the implementation of Education 5.0. Though teaching and learning were being offered online during the COVID-19 pandemic, some lecturers voiced their demands for support and further training to solve pedagogical problems in technological usage. Mechanisms therefore, need to be put in place to ensure that lecturers have adequate access to technology. Training was expressed as an important prerequisite for meeting challenges in technology use and helping in stimulating actual contexts which included online teaching pedagogy that is TPK. Thus, failure to have enough TPK for teaching online courses could hinder transition to ICT use in the classroom. Training of lecturers was found to be important for the effective use of technology as well as to integrate the technology for innovation and industrialisation.

ICT integration during COVID-19

It was found that the COVID-19 crisis signalled changes in technology that required different skills and forced universities to use online learning to teach Education 5.0. Harnessing ICT became key for participation and access to information. Using Zoom or Google Meet was perceived as successful tools to support the continuity of the learning process. Nonetheless, other means such as WhatsApp group were available to enhance students' interaction within the lecture sessions and assignment tasks that would create a less isolating environment for students. Technology enabled students to draw diagrams and fostered new thinking and provided real-time feedback to students. The TPACK framework explains that ICT supports lesson planning and aid student learning (Harris & Hofer 2011). It emerged that technology positively affected lesson flow, was cost effective, safe, and convenient, and enhanced participation. Moreover, the participant responses indicated that using ICT facilitated collaboration, communication, problem-solving and critical thinking during their teaching. In this instance, lecturers need to be trained in the use of ICT to yield optimum results in the implementation of Education 5.0. One challenge the lecturers faced was the lack of resources. As for the technological challenges, limited Internet connection seemed quite frustrating and had an impact on the continuity of the learning process. The data suggest that, instead, during COVID-19, some lecturers were learning about the platforms simultaneously as they were instructing students.

Methods of instruction used to teach education 5.0 during COVID-19

The findings indicated that the COVID-19 pandemic drastically changed modes of learning. Virtual teaching and learning activities were smarter, more engaging and interactive, and students could quickly explore vast bodies of knowledge. Thus, face-to-face learning was replaced by online or blended learning, which was not only safe but also quite effective. In this context, ICT tools can be utilised in teaching Education 5.0, including using YouTube to demonstrate skills. COVID-19 was regarded as a chance to make changes, therefore, being eager for the innovation and improvement in teaching that ICT could bring. Virtual learning enabled lecturers to upload documents, use YouTube videos, record lecture videos, and create online discussion forums. Moodle, Zoom, Video Conferencing, WhatsApp, Google Classroom, Microsoft Teams, and PowerPoint were used for the implementation of Education 5.0. Furthermore, research and project-based methods were used as part of continuous learning, and students were involved in online practical activities to encourage community engagement. Online learning facilitated the transformation of knowledge, sharpened interpersonal skills, and improved cognitive functions, meta-cognitive knowledge and academic success (Fong & Slotta 2018).

Internet connectivity, communication and interactivity

Access to digital devices and Internet infrastructure gave rise to digital learning platforms which provided an easy way out during the pandemic. Online classes were successful only if Internet facility was provided to all making it equitable and affordable. A lecturers' competency in

communication as well as ability to use the multimedia contents for effective presentation were very important. Interactivity was found to be one of the major driving forces of online classes. It was found that appropriate connectivity and recorded videos enabled lecturers to reach students virtually. Thus, connectivity allows students to shape their own learning ability (Galley *et al* 2014; Siemens 2005), leading to a progressive transformation of learner-centred, interactive and inquiry-based Education 5.0 (Tarling & Ng'ambi 2016). However, the biggest challenge reported by participants was technological constraints. It was found that during online learning students often had inadequate data. The lack of access to the Internet excluded some of the students from the online classes. Slow connections also made accessing course platforms and materials frustrating. It was also difficult for students to embrace the various teaching and learning technologies available. For example, Zoom and other meeting platforms had limitations for use in some contexts due to poor Internet connectivity. Therefore, the lecturers had to use WhatsApp during their teaching, which was more affordable.

CONCLUSION

The implementation of Education 5.0 required a shift from traditional theory-based education to a system that produces goods and services. The idea was to exploit natural resources, the environment, local knowledge and cultures. The COVID-19 pandemic initiated an extensive, sudden and dramatic digital transformation in universities. The online learning was found to be advantageous as it provided flexibility and convenience for the students. Flexibility in Education 5.0 is possible with technology because it facilitates following the student and supporting their education outside the classroom environment.

Technology allowed students to connect to a lesson on the other side of the world at any time and interact live with the lecturer and the subject material. Education was transformed from a traditional classroom practice to a remote, digitalised one. Thus, lecturers need to take the lead in this sudden, unexpected digital transformation of Education 5.0. The findings indicated that Education 5.0 knowledge has to be related to the theory and practice of teaching and learning. However, in our study Education 5.0 lacked clarity and support to lecturers, which adversely affected the implementation of Education 5.0-TPACK. A strong policy framework is necessary for successful innovation and industrialisation in universities.

Underpinning the use of ICT in teaching and learning is the importance of participation and access to information. It emerged that ICT remained a viable option in universities to facilitate access to information and that it helped reaching out to students during the COVID-19 lockdowns. The findings showed that technology gave students scientific information and provided access to models and diagrams and new thinking. ICT enhanced lecture presentations and real-time feedback. It also emerged that ICTs were cost and time effective, safe, and convenient and enhanced student participation. Using ICT in teaching enhanced the sharing of ideas, which helped achieve the objectives of Education 5.0. ICT helped lecturers meet the global requirements (mobility of goods, services, labour, technology and capital) to gradually substitute traditional teaching methods with technology-based teaching.

During the COVID-19 pandemic, online teaching and learning was the most effective and convenient method to continue lectures. It emerged that the methods of instruction that were essential for the implementation of Education 5.0 included digital platforms such as Moodle, Zoom, video conferencing, WhatsApp, Google Classroom, Microsoft Teams, and PowerPoint. Essentially, virtual teaching and learning activities were smarter, more engaging, interactive and allowed students to quickly explore a vast body of knowledge. Moreover, the lecturers could upload documents, use YouTube videos, record lecture videos, and create online discussion forums. Research and project-based methods were used as part of continuous learning.

Appropriate ICT resources and infrastructure for Education 5.0-TPACK support were essential for dynamic innovation and industrialisation. The availability of ICT resources in universities is a key component in the provision of quality Education 5.0. However, it emerged that the universities had unreliable devices, software and networks. This calls for universities to have well equipped laboratories, interactive whiteboards, projectors, computers and reliable Internet for the successful implementation of Education 5.0-TPACK.

It was evident that ICT knowledge and skills created more versatile and effective learning environments, which enhanced the delivery of information to the students. Moreover, it was evident that among lecturers there are differences in their digital skills and competencies. Therefore, it was difficult to adopt a proactive stance towards digital technology innovation and to design better tools to meet the needs of digitalised Education 5.0. Definitely, not all lecturers are in an equal position to engage in digitalised Education 5.0.

In this regard, digital transformation of Education 5.0-TPACK was seen as a core concern to empower lecturers to manage and master in their digital futures. However, a lack of access to the Internet will exclude some of the students from the online classes. Slow connections can also make accessing course platforms and materials frustrating. Thus, Education 5.0 can be successful only if the Internet facility is provided to all, making it equitable and affordable as was noted during the COVID-19 pandemic.

Therefore, in the Education 5.0-TPACK context, it is imperative that the mindset of lecturers be changed through seminars, workshops and site visits to make them appreciate the practical side of their work and to acquire ICT skills. In order for ICT to be effective, lecturers must be trained to use ICT in teaching and learning. Once the lecturers have the necessary knowledge and skills, they will be able to implement Education 5.0-TPACK in the classroom. Workshops and prioritising ICT pedagogic training could enhance lecturers' knowledge and skills to use teaching and learning platforms such as Moodle and Google Classroom. These platforms can empower lecturers to engage students and effectively implement Education 5.0. However, online learning required lecturers to develop technological knowledge for the adoption of ICT tools during their teaching.

Declarations

Availability of data and materials: Not applicable

Funding: No sources of funding

Acknowledgements

We give our sincere gratitude to the universities and participants for the guidance they offered during the data collection.

REFERENCES

Akkoç, H. 2011. "Investigating the development of prospective mathematics teachers' technological pedagogical content knowledge", *Research in Mathematics Education*, vol. 139 no.1, pp. 75–76. https://doi.org/10.1080/14794802.2011.550729

Almas, A. G., & Krumsvik, R. 2008. "Teaching in technology-rich classrooms: Is there a gap between teachers' intentions and ICT practices?" *Research in Comparative and International Education*, vol. 3, no. 2. DOI:10.2304/rcie.2008.3.2.103.

Angeli, C. & Valanides, N. 2009. "Epistemological and methodological issues for the conceptualisation, development, and assessment of ICT-TPCK: advances in technological pedagogical content knowledge (TPCK)", *Computers & Education*, vol. 52, pp. 154–168. https://doi.org/10.1016/j.compedu.2008.07.006

Archambault, L.M. & Barnett, J.H. 2010. 'Revisiting technological pedagogical content knowledge: exploring the TPACK framework', *Computers & Education*, vol. 55, no. 4, pp. 1656–1662. https://doi.org/10.1016/j.compedu.2010.07.009

Bhatia, S. 2018, 'Sustainable smart universities for smart cities', *Journal of Economics, Management and Trade*, vol. 21, no. 12, pp. 1–11. https://doi.org/10.9734/JEMT/2018/44521

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M. & Rumble, M. 2012. 'Defining 21st century skills', Griffin, P., McGaw, B. and Care E. (Ed.s), *Assessment and teaching of 21st century skills,* Springer, Dordrecht, pp. 17–66. https://doi.org/10.1007/978-94-007-2324-5

Botha, A. & Herselman, M. 2015. "ICTs in rural education. Let the game begin", Paper presented at the Sixth Annual Symposium on Computing for Development (ACM DEV 2015). London, UK.

Chai, C.S., Koh, J.H.L. & Koh, C.C. 2010. "Facilitating preservice teachers' development of technological, pedagogical, and content knowledge (TPACK)", *Educational Technology & Society*, vol. 13, no. 4, pp. 63–73.

Chai, C.S., Koh, J.H.L. & Tsai, C.C. 2013. "A review of technological pedagogical content knowledge", Educational *Technology and Society*, vol. 16, no. 2, pp. 31–51.

Cheng, K.H. 2017. "A survey of native language teachers' technological pedagogical and content knowledge (TPACK) in Taiwan", *Computer Assisted Language Learning*, vol. 30, no. 7, pp. 692–708. https://doi.org/10.1080/09588221.2017.1349805

Chitanana, L., Makaza, D., & Madzima, K. 2008. The current state of e-learning at universities in Zimbabwe: Opportunities and challenges. *International Journal of Education and Development using ICT*, vol. 4, no. 2, pp. 5-15.

Chitate, T. 2016. "Science, technology, engineering and mathematics (STEM): a case study of Zimbabwe's educational approach to industrialisation", *World Journal of Education*, vol. 6, no. 5, pp. 27–35. https://doi.org/10.5430/wje.v6n5p27

Davis, N., Preston, C. & Sahin, I. 2009, "ICT teacher training: evidence for multilevel evaluation from a national initiative", *British Journal of Educational Technology*, vol. 40, no. 1, pp. 135–148. https://doi.org/10.1111/j.1467-8535.2007.00808.x

Dede, C. 2010. "Technological supports for acquiring 21st century skills", Baker, E., McGaw, B., and Peterson, P. (Ed.s), *International encyclopedia of education* (3rd ed.), Elsevier, Oxford, pp. 158–166.

Djeflat, A. 2016. "Innovation hub in the steel sector in Algeria", in Adesida, O., Karuri-Sebina, G. and Resende-Santos, J. (Ed.s.), *Innovation Africa*, Emerald Group Publishing, pp. 343–395.

Doering, A., Koseoglu, S., Scharber, C., Henricksson, J. & Lanegran, D. 2014. "Technology integration in K-12 geography education using TPACK as a conceptual model", *Journal of Geography*, vol. 113, no. 6, pp. 223–237. https://doi.org/10.1080/00221341.2014.896393

El-Jardali, F., Ataya, N. & Fadlallah, R. 2018. "Changing roles of universities in the era of SDGs: rising up to the global challenge through institutionalizing partnerships with government and communities", *Health Research Policy and Systems*, vol. 16, no. 1, p. 38. https://doi.org/10.1186/s12961-018-0318-9

Ezumah, B, A. 2020. "Challenges of educational technology adoption in Africa." *Critical Perspectives of Educational Technology in Africa*. Springer.

Fong, C., & Slotta, J. D. 2018. "Supporting communities of learners in the elementary classroom: The common knowledge learning environment." *Instructional Science*, vol. 46, no. 4, pp. 1-29.

Galley, R., Conole, G. & Alevizou, P. 2014. "Community indicators: a framework for observing and supporting community activity on Cloud works", *Interactive Learning Environments*, vol. 22, no. 3, pp. 373–395.

Harasim, L., Hiltz, R.S., Teles, L. & Turoff, M. 1995. *Learning networks*. *A field guide to teaching and learning online*, The MIT Press, Cambridge, MA.

Harris, J.B. & Hofer, M.J. 2011. "Technological pedagogical content knowledge (TPACK) in action: a descriptive study of secondary teachers' curriculum-based, technology-related instructional planning", *Journal of Research in Technology Education*, vol. 43, no. 3, pp. 211–229. https://doi.org/10.1080/15391523.2011.10782570

Hennessy, S., Wishart, J., Whitelock, D., Deaney, R., Brawn, IaVelle, L., McFarlane, A., Ruthven, K. & Winterbottom, M. 2007. "Pedagogical approaches for technology-integrated science teaching", *Computers & Education*, vol. 48, no. 1, pp. 137–152. https://doi.org/10.1016/j.compedu.2006.02.004

Howell, J. 2012. *Teaching with ICT: digital pedagogies for collaboration and creativity*, Oxford University Press, Victoria, Australia.

Howland, J.L., Jonassen, D. & Marra, R.M. 2013. *Meaningful learning with technology* (4th ed.), Pearson Higher Education, New Jersey.

Hwee, J., Koh, L. & Chai, C.S. 2016. "Seven design frames that teachers use when considering technological pedagogical content knowledge (TPACK)", *Computers & Education*, vol. 102, pp. 244–257. https://doi.org/10.1016/j.compedu.2016.09.003

Isaacs, S. 2007. Survey of ICT and education in Africa: South Africa country, Re-report. Info Dev ICT and education series. World Bank, Washington.

Jena, N. 2017. "CUT embarks on artificial insemination programme to produce quality bulls", *Newsday*. 25 October, available at https://www.newsday.co.zw/2017/10/cut-embarks-artificial-insemination-programme-produce-quality-bulls/

Jiang, H., Jiang, P., Wang, D. & Wu, J. 2021. "Can smart city construction facilitate green total factor productivity? A quasi-natural experiment based on China's pilot smart city", *Sustainable Cities and Societies*, vol. 69, 102809. https://doi.org/10.1016/j.scs.2021.102809

Jimoyiannis, A. 2010. Integrating Web 2.0 in education: towards a framework for pedagogy 2.0, Hackney, R. and Evans, C. (Ed.s.), *Web 2.0 Conference Abstracts*, Brunel University, London, p. 5.

Jimoyiannis, A. & Angelaina, S. 2011), "Towards an analysis framework for investigating students' engagement and learning in educational blogs", *Journal of Computer Assisted Learning*, vol. 28, no. 3, pp. 222–234. https://doi.org/10.1111/j.1365-2729.2011.00467.x

Jimoyiannis, A., Tsiotakis, P. & Roussinos, D. 2013. "Social network analysis of students' participation and presence in a community of educational blogging", *Interactive Technology and Smart Education*, vol. 10, no. 1, pp. 15–30. https://doi.org/10.1108/17415651311326428

Jonathan, E. 2019. "Education 5.0—towards problem-solving and value creation", *Bulawayo 24News*, 1 March, available at https://bulawayo24.com/index-id-opinion-sc-columnist-byo-157170.html

Kabweza, L.S.M. 2011. Zimbabwe remains in the bottom ten of ICT Network Index, *TECHZIM*, available at www.techzim.co.zw/.../zimbabwe-remains-in-bottom-ten-of-i

Kangara, C, T, C., Gocha, M., Tsokota, T., & Marovah, T. 2022. Assessing readiness for teaching and learning using ICTs in Zimbabwean secondary schools in Gweru District, Zimbabwe. Research Square. https://doi.org/10.21203/rs.3.rs-1652431/v1

Keche, K. 2021. Relevance of new higher education approach in 'Second Republic Zimbabwe, Waller, L. (Ed.), *Higher education—new approaches to accreditation, digitalization, and globalization in the age of Covid*, Intech Open. http://dx.doi.org/10.5772/intechopen.99934

Koehler, M.J. & Mishra, P. 2009. "What is technological pedagogical content knowledge?", *Contemporary Issues in Technology and Teacher Education*, vol. 9, no. 1, pp. 60–70.

Koh, J. H. K., Chai, C. S., & Tsai, C. C. 2013. Examining practicing teachers' perceptions of technological pedagogical content knowledge (TPACK) pathways: A structural equation modelling approach. *Instructional Science*, vol. 41, no. 4.

Leal Filho, W., Brandli, L., Becker, D., Skanavis, C., Koumani, A., Sadi, C., Papaioa, D., Paco, A., Aceiteiro, U., Sousa, L., Baath, S., Pretorious, R., Shiel, C., Vargas, V., Trencher, G. & Marans, R. 2018. "Sustainable development policies as indicators and preconditions for sustainability efforts at universities fact or fiction", *International Journal of Sustainability in Higher Education*, vol. 5, no. 1, pp. 85–113. https://doi.org/10.1108/IJSHE-01-2017-0002

Levin, B. & Schrum, L. 2013. "Using systems thinking to leverage technology for school improvement: Lessons learned from award-winning secondary schools/districts", *Journal of Research on Technology in Education*, vol. 46, no. 1, pp. 29–51. ttps://doi.org/10.1080/15391523.2013.10782612

Lim, L.W. & Harwati, H. 2021. "Determining pre-service teachers' intention of using technology for teaching English as a second language (ESL)", *Sustainability*, vol. 13, no.14, p. 1568. https://doi.org/10.3390/su13147568

Lin, C.C., Tsai, C.S. & Lee, M.H. 2013. "Identifying science teachers' perceptions of Technological Pedagogical and Content knowledge (TPACK)", *Journal of Science Education and Technology*, vol. 22, no. 3, pp. 325–336. https://doi.org/10.1007/s10956-012-9396-6

Lubega, T. J., Mugisha, A. K., & Muyinda, P. B. 2014. "Adoption of the SAMR Model to assess ICT pedagogical adoption: A case of Makerere University." *International Journal of e-Education, e-Business, e-Management and e-learning* (IJEEEE), vol. 4, no. 2, pp. 106-115.

Lye, L.T. 2013. "Opportunities and challenges faced by private higher education institution using the TPACK model in Malaysia", *Procedia—Social and Behavioral Sciences*, vol. 91, pp. 294–305. https://doi.org/10.1016/j.sbspro.2013.08.426

Majola, M, X. 2020. Exploring learner-centred approaches in Business Studies grades 10-12. *The Independent Journal of Teaching and Learning*, vol.15, pp.101-113.

Malik, S., Rohendi, D. & Widiaty, I. 2018. "Technological Pedagogical Content Knowledge (TPACK) with information and communication technology (ICT) integration: a literature review", *Advances in Social Sciences, Education and Humanities Research* (vol. 299), 5th UPI International Conference on Technical Vocational Education and Training (ICTVET 2018).

Mandoga, E., Matswetu, V. & Mhishi, M. 2013. "Challenges and opportunities in harnessing computer technology for teaching and learning: a case of five schools in Makoni East District", *International Journal of Humanities and Social Sciences*, vol. 3, no. 1, pp. 105–112.

Mbunge, E., Fashoto, S., Akinnuwesi, B., Gurajena, C., Metfula, A. & Mashwama, P. 2020. "COVID-19 Pandemic in Higher Education: Critical Role of Emerging Technologies in Zimbabwe". Bulawayo: Zimbabwe.

Mishra, P. & Koehler, M.J. 2006. "Technological pedagogical content knowledge: a framework for teacher knowledge", *Teachers College Record*, vol. 108, no. 6, pp. 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

MoPSE. 2016c. ICT policy for primary and secondary education in Zimbabwe: Using ICTs to transform education and support sustainable socio-economic growth (Draft). Zimbabwe Education Ministry, Harare.

Mpungose, C.B. 2020. "Emergent transition from face-to-face to online learning in a South African university in the context of the Coronavirus pandemic", *Humanities & Social Sciences Communication*, vol. 7, Article 113. https://doi.org/10.1057/s41599-020-00603x

Musarurwa, C. 2011. Teaching with learning through ICT in Zimbabwe's teacher and e-education colleges. US-China Education Review A 7 (2011), pp. 952-959
Earlier title: US-China Education Review, ISSN 1548-6613

Muzira, D.R. & Bondai, B.M. 2021. "Perceptions of education towards the adoption of Education 5.0: a case study of a state university in Zimbabwe." *East African Journal of Education and Social* Science, vol. 1 no. 2, pp. 43–53. https://doi.org/10.46606/eajess2020v01i02.0020

Muzira, D.R. & Muzira, R. 2020. "An assessment of educators' level of concern on the adoption of Education 5.0: a case of one university in Zimbabwe". *Current Journal of Applied Science and Technology*, vol. 39, no. 17, pp. 22–32. https://doi.org/10.9734/cjast/2020/v39i1730749

Nadolny, L., Alaswad, Z., Culver, D. & Wang, W. 2017. "Designing with game-based learning: game mechanics from middle school to higher education", *Simulation & Gaming*, vol. 48, no. 6, pp. 814–831. https://doi.org/10.1177/1046878117736893

Pamuk, S., Ergun, M., Cakir, R., Yilmaz, H.B. & Ayas, C. 2015. "Exploring relationships among TPACK components and development of the TPACK instrument", *Education and Information Technologies*, vol. 20, no. 2, pp. 241–263. https://doi.org/10.1007/s10639-013-9278-4

Partnerships for 21st Century Skills. 2009. *A framework for 21st century learning*, P21, Tucson, AZ.

Pondiwa, S. 2021. Integration of ICT and education in Africa: Lessons learnt at the State University of Zanzibar and the Midlands State University in Zimbabwe. Intech Open. http://dx.doi.org/10.5772/intechopen.984.41

Richard, H., & Haya, A. 2009. Examining student decision to adopt Web 2.0 Technologies: Theory and Empirical tests. *Journal of Computing in Higher Education*.

Saavedra, A.R. & Opfer, V.D. 2013. "Learning 21st-century skills requires 21st century teaching", *Phi Delta Kappan*, vol. 94, no. 2, pp. 8–13. https://doi.org/10.1177/003172171209400203

Sangrã, A. 2001. "Present and future use of technologies in education", Keynote speech at the IV EDEN Open Classroom Conference, November, in Barcelona.

Sayed, Y. & Ahmed, R. 2011. "Education quality in post-apartheid South African policy: balancing equity, discovery, rights and participation", *Comparative Education*, vol. 47, no. 1, pp. 103–118. https://doi.org/10.1080/03050068.2011.541680

Schleicher, A. 2020. "The impact of COVID-19 on education insights from education at a glance 2020", available at https://www.oecd.org/education/the-impact-of-covid-19-on-education-insights-education-at-a-glance-2020.pdf

Schmidt, D. A., Baran, E., Thompson, A. D., Kochler, M. J., Mishra, P., & Shin, T. 2009. "Technological pedagogical content knowledge (tpack): The development and validation of an assessment instrument for preservice teachers". *Journal of Research on Technology in Education*, vol. 42, no. 2, pp. 123-149.

Shoemaker, D., Rainey, J.L. & Wilson, C. 2012. "A governance framework for ICT supply chain risk management", *EDPACS*, vol. 46, no. 6, pp. 1–8. https://doi.org/10.1080/07366981.2012.748557

Shulman, L.S. 1986. “Those who understand: knowledge growth in teaching”, *Educational Researcher*, vol. 15, no. 2, pp. 4–14. https://doi.org/10.3102/0013189X015002004

Siemens, G. 2005. “Connectivism: a learning theory for the digital age”, available at http://www.elearnspace.org/Articles/connectivism.htm (accessed 10 September 2014).

Sizer, T.R. & Sizer, N.F. 1999. The students are watching schools and the moral contract, *Beacon Press*, Boston.

Tarling, L. & Ng’ambi, D. 2016. “Teachers’ pedagogical change framework: a diagnostic tool for changing teachers’ uses of emerging technologies”, *British Journal of Educational Technology*, vol. 47, no. 3, pp. 554–572. https://doi.org/10.1111/bjet.12454

Tee, M. and Lee, S. 2011. “From socialization to internalization: cultivating technological pedagogical content knowledge through problem-based learning”, *Australasian Journal of Educational Technology*, vol. 27, no. 1, pp. 89–104. https://doi.org/10.14742/ajet.984

Tirivangana, A. 2019. “Education 5.0 and Vision 2030 … re-configuring Zimbabwe university degrees”, available at https://www.thepatriot.co.zw/education/education-5-0-and-vision-2030-re-configuring-zim-university-degrees/

Togo, M. & Gandidzanwa, P.C. 2021. “The role of Education 5.0 in accelerating the implementation of SDGs and challenges encountered at the University of Zimbabwe”, *International Journal of Sustainability in Higher Education*, vol. 27 no. 7, pp. 1520–1535. https://doi.org/10.1108/IJSHE-05-2020-0158

Totten, S., Sills, T., Digby, A. & Russ, P. 1991. *Cooperative learning: a guide to research*, Garland, New York, NY.

Tsiotakis, P. & Jimoyiannis, A. 2014. “Collaboration and community building in an online teacher community of learning: a social network analysis”, Ortiz, G., Troubitsyna, E. and De Agostino, S. (Ed.s.), *Proceedings of the ninth international conference on internet and Web applications and services- ICIW2014*, 20–24 July, 2014, Paris, France, pp. 19–24.

Tsvuura, G., Mbawuya, K.D. & Ngulube, P. 2021. “Creation and storage of records in the cloud by Zimbabwe Open University”, *Journal of the Eastern and Southern Africa Regional Branch of the International Council on Archives*, vol. 40, pp. 1–20. https://doi.org/10.4314/esarjo.v40i1.1

Utomo, H.P., Bon, T.T. & Hendayun, M. 2017. “The integrated academic information support for Education 3.0 in higher education institution: lecturer perspective”, International Post Graduate Conference on Applied Science and Physics, *Journal of Physics*, IOP Publishing.

Victoria, T.L. 2011. “ICT in education”, available at http:enwiki.books.org/wiki? (accessed 13 June 2012).

Voogt, J., Fisser, P., Pareja, R.N., Tondeur, J. & van Braak, J. 2013. “Technological pedagogical content knowledge—a review of the literature”, *Journal of Computer Assisted Learning*, vol. 29, no. 20, pp. 109–121. https://doi.org/10.1111/j.1365-2729.2012.00487.x

Winter, J. & Cotton, D. 2012. “Making the hidden curriculum visible: sustainability literacy in higher education”, *Environmental Education Research*, vol. 18, no. 6, pp. 783–796. https://doi.org/10.1080/13504622.2012.670207

Wu, W.H., Chen, W.F., Wang, T.L. & Su, C.H. 2008. “Developing and evaluating a game-based software engineering educational system”, *International Journal of Engineering Education*, vol. 24, no. 4, pp. 681–688.

Yakovleva, N.O. & Yakovlev, E.V. 2014. “Interactive teaching methods in contemporary higher education”, *Pacific Science Review*, vol. 16, no. 2, pp. 75–80. https://doi.org/10.1016/j.pscr.2014.08.016

Yin, R. K. (2009). Case study research: Design and methods (4th Ed.). Thousand Oaks, CA: Sage.

Zhou, L., Wu, S., Zhou, M. & Li, F. 2020. “Schools out, but class on, the largest online education in the world today: taking China’s practical exploration during the COVID-19 epidemic prevention and control as an example.” *Best Evidence of Chinese Education*, vol. 4, no. 2, pp. 501–519. https://doi.org/10.15354/bece.20.ar023
