
How do South African TVET lecturers rate their digital competencies, and what is their need for training for a digital transformation in the South African TVET sector?

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ABSTRACT

Digital-transformation processes pose many challenges for South African technical and vocational education and training (TVET) colleges. In addition to improving infrastructure, lecturers must be equipped with new knowledge and skills to face the challenges in 21st-century classrooms and workforces. Based on the technological pedagogical content knowledge (TPACK) model, this study investigated the ways in which TVET lecturers (n = 364) self-assess their competence in digital teaching and learning, and the kind of additional training or support that they need to increase the effectiveness of their digital teaching. The findings suggest that the lecturers' self-assessments of their digital-related knowledge are generally high. In addition, the sub-dimensions of TPACK differ significantly according to the educational background of a lecturer. Those with a regular teacher education rate their TPACK abilities higher than those who have only subject-specific training or a pedagogical education. Nevertheless, analysis of the qualitative data shows that TVET lecturers need extensive support in planning effective technology-enhanced lessons, including the creation of educational content.

KEYWORDS

Professionalisation of TVET lecturers; technological pedagogical content knowledge (TPACK); digital competence; technical and vocational education and training (TVET); South Africa

Context and theoretical background

A common discourse on digitalisation in South Africa is concerned with opportunities to improve the quality of education, and to offer solutions (e.g. distance education) to long-standing problems, such as the inequalities arising from multilingualism and restricted access in rural areas (Langthaler & Bazafkan, 2020). Furthermore, findings show that the adoption of digital technologies could lead to a threefold growth in productivity in South Africa, which could be expected to generate up to 1.2 million jobs by 2030 (Magwentshu et al., 2019).

The need for digital skills has already increased in most major sectors in post-1994 South Africa. Standard digital technologies such as email or instant messaging for communication, video-conferencing applications, the Internet, and computer hardware and software are already pervasive in the workplace. For this reason, TVET college students must acquire these technologies in order to participate meaningfully in learning activities (Twinomurinzi, Msweli & Phukubje, 2020; Denhere & Moloji, 2021b:232). In addition, there is a growing need for specific or advanced digital technologies (Guthrie et al., 2009) that are related to Industry 4.0: these include artificial intelligence (AI), robotics and/or 3D technologies used specifically to perform certain tasks. In particular, the mining, manufacturing and service sectors are undergoing significant transformation due to the implementation of a range of advanced technologies (DCDT, 2020).

While the share of high-skilled jobs in the economy is increasing, South Africa has faced high unemployment for many years, with a rate of 35.3% in the fourth quarter of 2021, and 44.7% for young people between the ages of 15 and 34 years (SSA, 2022). A higher proportion of highly skilled workers is participating in the labour market, whereas low-skilled workers are struggling to find employment (DHET, 2022). Owing to ongoing digital automation and transformation, it is expected that this gap will widen. This means that an individual's digital competence is critical to their obtaining work opportunities in South Africa (Matli & Ngoepe, 2020). However, in surveys, it has been revealed that even the so-called 'digital natives' can lack basic digital skills (Czerniewicz & Brown, 2013).

Against this background, the South African government has published eight main interconnected elements that respond to the challenges arising from the increasing deployment and adoption of digital technologies (DCDT, 2020). Aligned with the most recent definitions of digital inclusion (Djukic, 2022) and digital competence (Ferrari, Punie & Redecker, 2012; EU, 2018), the strategy includes the aim of improving the ability of South Africa's citizens to access and use digital technologies for multiple purposes. Among them are information, media and data literacy, communication and collaboration, digital-content creation, safety, devices and software operations, and problem-solving. These are all needed for citizens to be prepared for 21st-century learning, the contemporary world or work, and society in the Digital Age (DCDT, 2021:8–9).

In response to these needs, educational systems – in particular TVET – must be transformed in order to respond to the desire to develop digital competence (Naudé, 2017; Makgato, 2020). Consequently, TVET lecturing staff are required to acquire a certain number and degree of competencies, since knowledge and pre-existing beliefs about the educational value of technology have proved to influence the ways in which teachers deal with technologies both as a means of delivery and as content (cf Ertmer et al., 2012; OECD, 2019; Gretch & Camilleri, 2020).

Digital competence of educators

Several frameworks and models which describe educators' competence and skills in relation to digital technology have been developed at the national and international levels. The concepts of these frameworks and models differ in their structure and in the nature and level of competence required by educational staff, in addition to their theoretical connectivity. Often the selection of areas, criteria and aspects to describe and assess digital competence involves unclear criteria and lacks scientific validity and reliability. Most models are claimed to be more practice-oriented than scientific. Nevertheless, the frameworks and models indicate agreement about the fact that teachers need pedagogical knowledge that is relevant to their subject content in order to use relevant technology for educational purposes. The best-known and most influential digital competence frameworks for educators are the European framework for digital competence of educators (Redecker, 2017), the technological pedagogical content knowledge model (Mishra & Koehler, 2006; Koehler et al., 2014), and the UNESCO information and communications technology (ICT) competency framework for teachers (UNESCO, 2018).

In particular, TPACK has become an influential model that is used to describe the required educators' structures of knowledge for the use of technology in the classroom. In the TPACK model, the complex relationship between technological knowledge (TK), content knowledge (CK) and pedagogical knowledge (PK) is described, as are the following three overlapping areas: pedagogical content knowledge (PCK), technological content knowledge (TCK) and technological pedagogical knowledge (TPK). These are in addition to the overarching TPACK (Mishra & Koehler, 2006). Because it can be assumed that the model obeys quality criteria for models such as precision, simplicity, generality and fruitfulness (Kuhn, 1977) for embedding technology and digitisation-related elements in teaching–learning contexts (Tondeur et al., 2021), the model was used as the basis for this study. The criteria of *scope* and *fruitfulness* of this model are considered to be important, since TPACK is the most frequently cited model of the digital competence of teachers (*scope*), and many empirical studies have applied the model. Therefore, the framework facilitates international comparability about teachers' TPACK (Kimmons & Hall, 2018). Furthermore, the model has roots in the standard models of teachers' professional knowledge (e.g. Shulman 1987); and therefore it seems to be fully compatible with theoretical and educational practice.

Based on the Policy on Professional Qualifications for Vocational Education Lecturers, successful South African TVET lecturers are characterised as possessing a combination of

specialised content knowledge, and pedagogical–psychological and didactic skills. Furthermore, professionally qualified South African lecturers ‘must be personally competent users of ICTs, as well as being able to integrate ICTs effectively in teaching and learning’ (DHET, 2013:36). This integration of ICTs may be the use of language learning applications for first- and second-language education, and the use of a simulation software for learning mathematics (DCDT, 2020:21). Regarding industry-related skills, TVET lecturing staff must also be aware of new and evolving digital trends and tools related to the world of work, and they must acquire specialised knowledge about the equipment and machines used specifically to perform a particular job scope (Guthrie et al., 2009).

However, qualitative research suggests that a qualification gap exists among TVET lecturers and that the use of digital technologies does not meet the requirements of a digital society and the professional world (Ngubane-Mokiwa & Khoza, 2016; Naiker & Makgato, 2018; Denhere & Moloji, 2021a) – even if lecturers’ perceptions indicated their readiness and willingness to use digital technologies in their classrooms (Mbanga & Mtembu, 2020; Denhere & Moloji, 2021a). A lack of training for teaching staff on the use of available technologies, a lack of computing equipment and ICT infrastructure, and, above all, a lack of policy directives for TVET colleges are obstacles to the integration of digital technology in these colleges. Similar findings are to be found across international contexts, where such first-order barriers (e.g. limited equipment, training, and support) are necessary but insufficient conditions for the use of technology in the classroom (Ertmer et al., 2012; Schmitz et al., 2022). In contrast, teachers often have positive beliefs about digital technologies (Sailer et al., 2021) and they generally rate their digital skills (including those of TPACK) as ‘good’ to ‘very good’ (Chai, Koh & Tsai, 2010). Nevertheless, teachers express a need for training, saying that they want to develop their knowledge of TPACK in their classrooms (Redmond & Lock, 2019). In a South African context, Sherman and Howard (2012) identified barriers to STEM teachers’ technology use originating from sociocultural norms (e.g. a desire for control). The authors argued that these factors could have an impact on the teachers’ beliefs about technology and teaching and thus inhibit their adoption of more student-centred pedagogies and technology integration.

At a more quantitative level, little is known about South African TVET lecturers’ competencies and beliefs related to digital teaching and learning. Teis and Els (2021) have shown that 52.3% of the participating lecturers (n = 577) in Technical Engineering are unaware of any industry-relevant 4IR (Fourth Industrial Revolution) technologies in their area of specialisation. Furthermore, most participants rated their knowledge of the practical use and application of 4IR technologies as being of a very high level. However, considering that almost 50% of the participants did not indicate this test item, the results must be interpreted with caution. It could also be assumed that those non-responses suggest participants’ lack of competence (Teis & Els, 2021).

Research goals and methods

In the light of the outlined importance of promoting digital competence for social and economic development in South Africa, and given that lectures are drivers of the development of digital skills, the study aimed to investigate the knowledge TVET lecturers possess of digital technology, pedagogy and content. The lecturers' perceived needs and recommendations for in-service training were also examined. Regarding the limited empirical findings on South African TVET lecturers' knowledge and use of technology, a non-experimental exploratory research design was chosen, using a questionnaire as a data-collection instrument based on the TPACK model elaborated by Mishra and Koehler (2006).

Since teachers need varied professional training to develop their digital competence, depending on their background and stage of developmental (Stroot et al., 1998; Berliner, 2004), the findings of the study are to be used to develop evidence-based training for TVET lecturers, corresponding to the terms of training content and organisation of training. The following research questions (RQs) were raised and responded to in this study:

- RQ1: What self-reported digital technology, pedagogy and content knowledge (TPACK) do TVET lecturers possess?
- RQ2: How do TVET lecturers make use of digital technology in daily instructional practices with their students?
- RQ3: What training content related to digital teaching and learning do TVET lecturers want?
- RQ4: What recommendations on the design and delivery of digital competence training for teaching and learning do the lecturers have?

Data collection

The data were collected from May to November 2021, using online questionnaires. The Department of Higher Education and Training (DHET) invited all principals of the 50 public colleges through emails to share the link to the online survey with their lecturing staff. Participation in the study was voluntary and the data were collected anonymously.

Description of the instruments

The survey instrument consisted of five sections, A–E. Section A collected the following background variables from the participants:

- Demographic information (gender, age group, highest level of formal education);
- Major area of study;
- Practical training;
- Teaching qualification;
- Teaching and work experience;

- In-service professional-development activities;
- Teaching subjects; and
- Location of campus.

Section B comprised 12 items measuring their beliefs about teaching and learning (items were adopted from TALIS, 2008). However, the empirical findings from this information category are not reported on in this article. Section C measured the use of technology by lecturers in their lessons. Section D included a closed-question area on the seven knowledge scales of the TPACK questionnaire by Schmidt et al. (2009), and in its extended form by Zinn et al. (2022). The items by Zinn et al. were translated into English via back-translation (Brislin, 1970). The responses were measured on a 5-point Likert scale (from 1 – completely disagree to 5 – completely agree). The reliability values achieved in the individual scales can be described as ranging from ‘good’ to ‘very good’ (see Table 1). An open-ended question area in Section D was related to the use of technology and the need for training. The participants were asked to describe a specific episode in a lesson where they combined content, technologies and pedagogical approaches. Section E was composed of 10 items on self-efficacy based on the work of Schwarzer and Jerusalem (2002). The questions used a 4-point Likert scale (from 1 – strongly disagree to 4 – strongly agree).

Table 1: Reliability values of the TPACK scales, and examples of items in the questionnaire

SCALE	ITEM COUNT	RELIABILITY	SUBJECT-RELATED	ITEM EXAMPLE
Technological knowledge (TK)	6	0.89	✗	I know how to solve my own technical problems.
Content knowledge (CK)	3	0.84	✓	I have sufficient knowledge about my first teaching subject.
Pedagogical knowledge (PK)	6	0.93	✗	I know how to assess student performance in a classroom.
Pedagogical content knowledge (PCK)	6	0.93	✓	I can select effective teaching approaches to guide student thinking and learning in my first teaching subject.
Technological content knowledge (TCK)	5	0.88	✓	I know about technologies that I can use for understanding and doing my first teaching subject.
Technological pedagogical knowledge (TPK)	9	0.95	✗	I can choose technologies that enhance the teaching approaches for a lesson.
Technological pedagogical content knowledge (TPACK)	8	0.95	✓	I can combine my first teaching subject knowledge, digital media and teaching methods in the classroom in a way that efficiently supports the teaching process.

Description of the sample

In total, a random sample of lecturers (n = 366) teaching in different subject domains (STEM, Business & Utility Studies, Humanity Studies) at South African public TVET colleges completed the survey instrument. Of these, n = 2 lecturers were excluded due to response behaviour. The gender distribution of the final sample (n = 364) was n = 179 (49.2%) females and n = 185 (50.8%) males. The average teaching experience of the TVET lecturers was 13.27 years (median = 10.50 years). The subjects frequently mentioned were Management, Finance & Marketing (n = 144), Mechanical Engineering (n = 123) and Electrical Engineering (n = 99). The age of the study participants ranged from under 25 years (0.5%) to 60 years or older (12.4%). Most of the participants were in the 30 to 49-year age group. The colleges at which they taught are situated in the Eastern Cape (9), Free State (6), Gauteng (44), KwaZulu-Natal (12), Limpopo (6), Mpumalanga (5), North West (66) and the Western Cape (222). The Northern Cape is not represented. As far as participation in training within the past 12 months was concerned, 50.5% (n = 184) had participated in professional-development activities; 25.5% of the participants (n = 93) referred to training in ICT in Teaching and Management, whereas only 1.15% (n = 4) had attended a programme in digital teaching and learning.

Analysis and results

Descriptive results of the self-assessments

The quantitative data were evaluated using the statistical software R. Overall, the lecturers assessed their teaching-related knowledge (CK, PCK, PK) as being in the upper range of the scale (see Table 2). In the technology-related areas, they consistently rated themselves lower. The overall assessment for each scale is nevertheless above the scale mean of three, with a slightly higher standard deviation than for the teaching-related self-assessment.

Table 2: Descriptive results in the seven knowledge domains

	TOTAL SAMPLE
Scale	mean (SD)
Technological knowledge (TK)	3.65 (0.73)
Content knowledge (CK)	4.30 (0.54)
Pedagogical knowledge (PK)	4.33 (0.51)
Pedagogical content knowledge (PCK)	4.24 (0.51)
Technological content knowledge (TCK)	3.64 (0.75)
Technological pedagogical knowledge (TPK)	3.93 (0.67)
Technological pedagogical content knowledge (TPACK)	3.73 (0.76)

Comparison between subgroups

In order to identify possible differences among the variables in TVET lecturers' backgrounds, an analysis of variance (ANOVA) was used. The results of the ANOVA indicated no significant differences between gender, teaching subject and location of the college.

Stage theory models of teacher development imply that teachers at different career stages may possess different competences and therefore have different training needs (Stroot et al., 1998; Berliner, 2004). Regarding the digital competence of teachers, indications are that older lecturers with more professional experience rate their competence lower (Guggemos & Seufert, 2021). In spite of these results, the lecturers were categorised into three groups according to their teaching experience. The categorisation was based on the theory of Huberman (1989).

Table 3: Results according to the different stages of lecturers' development

	ENTRY & STABILISATION	PROFESSIONAL DEVELOPMENT	CONSERVATISM, SERENITY & PROFESSIONAL ENDINGS	ANOVA	TUKEY-HSD
	mean (SD)	mean (SD)	mean (SD)		
TK	3.74 (0.76)	3.75 (0.71)	3.37 (0.66)	F(2, 361) = 10.30***	ES-PD ES-CSPE** PD-CSPE***
PK	4.25 (0.52)	4.32 (0.51)	4.43 (0.48)	F(2, 361) = 3.33*	ES-PD ES-CSPE* PD-CSPE
TPK	3.86 (0.73)	4.04 (0.61)	3.79 (0.69)	F(2, 361) = 5.04**	ES-PD ES-CSPE PD-CSPE**
CK	4.23 (0.53)	4.31 (0.58)	4.34 (0.47)	F(2, 641) = 1.86	ES-PD ES-CSPE PD-CSPE
PCK	4.18 (0.48)	4.24 (0.55)	4.28 (0.46)	F(2, 664) = 1.75	ES-PD ES-CSPE PD-CSPE
TCK	3.70 (0.76)	3.75 (0.73)	3.37 (0.72)	F(2, 668) = 16.78***	ES-PD ES-CSPE*** PD-CSPE***
TPACK	3.81 (0.72)	3.8 (0.75)	3.52 (0.77)	F(2, 662) = 9.35***	ES-PD ES-CSPE*** PD-CSPE***

ES = Entry & stabilisation; PD = Professional development; CSPE = Conservatism, serenity & professional endings.

Significance levels are indicated by asterisks and correspond to the following p-values:

** < 0.05 (significant), ** < 0.01 (highly significant), *** < 0.001 (most significant).*

Lecturers with the most experience in teaching tend to rate themselves lower than new lecturers in the technological and technological–pedagogical areas (see Figure 1 and Table 3). At the same time, they rate themselves higher in all non-technological facets than lecturers with comparatively less professional experience. However, a uniform tendency can be observed only to a limited extent based on this normative differentiation criterion. In order to gain a deeper understanding of self-assessed competence, a cluster analysis was conducted in the following section.

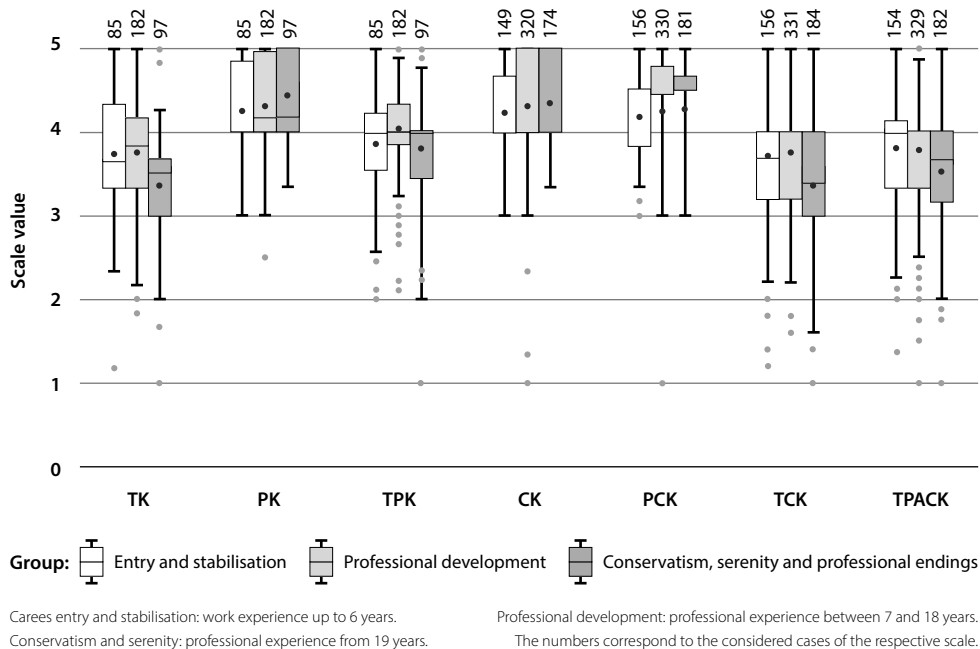


Figure 1: Breakdown of the sample according to stages of professional experience

Cluster analysis for comparison between subgroups

TVET lecturers enter the profession from a range of different backgrounds and possess different competences, and therefore have different training needs. The aim of using a cluster analysis is to exploratively identify groups that rate themselves differently from other groups in the TPACK domains via k-means clustering. Within the clusters, an analysis can be conducted, both quantitatively and qualitatively, in order to group objects or individuals based on similarities. The optimal number of clusters was determined by using the *NbClust* Package, which compares 23 indices in order to determine the best number of clusters (Charrad et al., 2014). Three clusters were suggested as the best fit for the data.

In Cluster 1, there are $nC1 = 80$, in Cluster 2 there are $nC2 = 170$, and in Cluster 3 there are $nC3 = 108$ respondents. It is noticeable that Cluster 1 is the oldest group (24% of the group

is younger than 40 years) and differs significantly in age from Cluster 3 (43% of the group is younger than 40 years). There is no significant age difference between Clusters 1 and 2 and Clusters 2 and 3. Furthermore, there is no significant group difference between the clusters in terms of professional experience. The composition of the clusters shows that in Cluster 1, 55% of the lecturers had not received any concurrent or consecutive teacher training. In Cluster 2, this applies to 41% of the lecturers. In Cluster 3, 54% of the lecturers had not received any concurrent or consecutive teacher training.

Table 4: Overview of the characteristic values of the individual clusters (Mean values and standard deviations are reported unless otherwise defined by the variable in the left column)

	CLUSTER 1	CLUSTER 2	CLUSTER 3	ANOVA/WELCH-ANOVA ^[W]	TUKEY-HSD/GAMES-HOWELL ^[W]
	mean (SD)	mean (SD)	mean (SD)		
NCluster	80	170	108	–	–
Teaching experience	13.34 (9.75)	13.13 (8.99)	13.49 (9.83)	F(2, 355) = 0.05	C1–C2 C1–C3 C2–C3
Age ¹	4.36 (1.08)	4.12 (1.09)	3.95 (1.16)	F(2, 355) = 3.138*	C1–C2 C1–C3* C2–C3
Age subgroup counts:	0	1	1	---	-----
NCat. 1	2	7	6	--	
NCat. 2	17	46	39		
NCat. 3	25	51	24		
NCat. 4	22	47	27		
NCat. 5	14	18	11		
TK	2.94 (0.66)	3.72 (0.51)	4.06 (0.65)	F ^[W] (2, 175) = 68.9***	C1–C2*** C1–C3*** C2–C3***
PK	4.08 (0.55)	4.12 (0.35)	4.86 (0.25)	F ^[W] (2, 177) = 228***	C1–C2 C1–C3*** C2–C3***
TPK	3.10 (0.50)	3.96 (0.30)	4.53 (0.50)	F ^[W] (2, 159) = 192***	C1–C2*** C1–C3*** C2–C3***
CK	4.18 (0.48)	4.05 (0.34)	4.83 (0.25)	F ^[W] (2, 181) = 247***	C1–C2 C1–C3*** C2–C3***
PCK	4.00 (0.50)	4.01 (0.27)	4.79 (0.27)	F ^[W] (2, 171) = 294***	C1–C2 C1–C3*** C2–C3***

	CLUSTER 1	CLUSTER 2	CLUSTER 3	ANOVA/WELCH-ANOVA ^[W]	TUKEY-HSD/GAMES-HOWELL ^[W]
TCK	2.73 (0.53)	3.67 (0.40)	4.19 (0.59)	F ^[W] (2, 170) = 162***	C1–C2*** C1–C3*** C2–C3***
TPACK	2.72 (0.67)	3.80 (0.32)	4.24 (0.61)	F ^[W] (2, 149) = 132***	C1–C2*** C1–C3*** C2–C3***

Significance levels are indicated by asterisks and correspond to the following p-values: * < 0.05 (significant), ** < 0.01 (highly significant), *** < 0.001 (most significant). ¹ Age was recorded as a categorical variable. The scale is structured according to the following subdivision: 1 = under 25 years old; 2 = 25–29 years old; 3 = 30–39 years old; 4 = 40–49 years old; 5 = 50–59 years old; 6 = 60 years or older.

Table 5: Overview of participation in a training course within the past 12 months in Clusters 1–3

	CLUSTER 1	CLUSTER 2	CLUSTER 3	SUM
	Number surveyed	Number surveyed	Number surveyed	Number surveyed
Total in cluster	80	170	108	358
Knowledge and understanding of subject field	26	71	36	133
Pedagogical competencies	15	39	27	81
ICT	9	48	33	90
Programmable robots and microcontroller	1	2	6	9
Computer-aided design (CAD)	1	4	8	13

From the results in Table 4 and 5, it is apparent that the composition of Clusters 1 and 3 is very similar regarding initial training but differs as far as age is concerned. It can be concluded that older lecturers assessed their skills at using technologies and their application in pedagogy contexts lower than the group of younger lecturers with the same educational background (cf Seufert et al., 2019). Members of Cluster 2 also self-assessed their knowledge significantly higher than those in Cluster 1 regarding the technology-related facets, but differed from those in Clusters 1 and 3 in the composition according to level of education. Here, lecturers in the consecutive and concurrent level of education achieved a slightly higher competence assessment for the technology-related facets. This suggests that these individuals were exposed to the use of technology in a didactic context during their initial training or had increased their participation in continuing education in ICT. This assumption is also supported by the number of times the lecturers participated in continuing education in the clusters (see Table 5). In Clusters 2 and 3, about 30% of the

lecturers had taken part in ICT training within the past 12 months, whereas in Cluster 1 only 10% stated that they had taken part in such training.

The level of self-assessment in Clusters 1 and 3 is not directly evident from their demographic data but could be related to their previous professional background, current technology use, and training needs.

Qualitative data and analysis of group differences

Owing to the high self-assessment in the technology-related areas in Cluster 3, the clusters were subjected to a qualitative analysis concerning their current use of technology.

In research, it has been indicated that there are differences between the needs of teachers at their various stages of teaching development (Stroot et al., 1998; Berliner, 2004). In order to identify the characteristics of in-service teacher training (see RQ3 & RQ4) that responds to the learning needs of teachers over their career span and arouses the motivation and commitment required to improve teaching standards, lecturers' responses to Section D on their needs and recommendations regarding training, were also analysed. The data were analysed based on a structured content analysis according to Mayring (2015) using the MAXQDA software (Versions 11 & 22).

Technology use

An important difference was found among the three clusters regarding the use of technology. Twenty out of 80 participants in Cluster 1 indicated that they had not used technologies, whereas, in Cluster 2, 10 participants out of 170, and, in Cluster 3, 3 out of 108 had not (regularly) implemented technologies. There were no significant differences among the three groups in respect of technology use for the delivery of instruction. The results show that, in all groups, lecturers frequently used PowerPoint to make presentations, and utilised multimedia content (e.g. videos) to support the students' understanding in or outside the classroom. Usually, the lecturers made use of open multimedia resources and rarely of self-recorded videos (e.g. slidecasts). Along with this, the most frequently used technological device to share content for instructional purposes was the projector, whereas the use of a visualiser and a smart board was less frequently mentioned. Lecturers also deployed instant messaging (e.g. WhatsApp) for sharing content and for communication. Nevertheless, the use and integration of technologies in Clusters 2 and 3 were more multi-variant. Here – even if reported less frequently – lecturers used digital clipboards, blogs and e-books. Lecturers in Cluster 2 and 3 also used standardised tests or quizzes, subject-specific tools (e.g. Geogebra) and simulations (e.g. CAD) during their classes. Two lecturers explained:

When I taught jewellery, I used Rhino to show the students a model ring and they could clearly see the front, side and top view before they started manufacturing

it. It helped me because I did not need to physically manufacture the ring, but constructed it on Rhino 3-D software (female, 40–49 years, STEM, 3, 287).¹

...[As regards t]he different oil pumps, ... I asked a friend to make a drawing into a GIF ... [s]o the students [could] see how the part moves. This [was also] circulated to the students via the WhatsApp chat group. I also used the Aver Visualiser to show a part (Motor Technology) on the inside, via the data projector (male, 50–59 years, STEM, 2, 271).

Although many lecturers generally used technology more for presentation and demonstration than to engage in student learning activities, others followed an integrated approach and made more conscious decisions about technological applications in favour of student engagement:

Teaching public-speaking skills. Student-centred and group approach. Using the Internet to review famous speeches. Conducting research and analysing speeches. Audiovisual sessions using MS Teams and WhatsApp voice notes. Integrated approaches. Whiteboard, laptop, the Internet, WhatsApp (female, 50–59 years, HADS, 3, 274).

Using Moodle in class, I display the work on the whiteboard while students log in at their end to access the work. This saves paper, time writing the notes, and allows more time explaining but, most importantly, interacting with discussions (female, 30–39 years, BUS, 3, 279).

As part of teaching Communication in English, I combine it with their ICT unit, where I let the students do research, which they then have to present in a PowerPoint format. I would spend a few lessons to demonstrate and guide them on (a) using various search engines to gain information on a topic, and (b) summarising that information by creating a PowerPoint presentation (female, 50–59 years, BUS/HADS, 2, 9).

Regarding Moodle, lecturers report that they use this teaching tool to share material or quizzes. Video-conferencing units were rarely used by lecturers. Other technologies commonly used in Clusters 2 and 3 included devices and tools associated with occupational areas (e.g. CAD, Office software) or ICT:

When teaching Entrepreneurship, using computers [and] calculators in trying to make the student understand the real world when doing calculations in [respect of the] finances of the business (male, 25–29 years, BUS, 2, 162).

1 Gender, age, teaching domain (STEM, BUS, HADS), cluster, questionnaire number.

The most frequent activity involving students using technology in the classroom was conducting research (e.g. Internet searches). Other activities commonly described were preparing written text (e.g. doing word processing), corresponding and sharing content with others (e.g. students and lecturers) via instant messaging, and developing and making presentations (e.g. by way of PowerPoint). Often, students engaged in technology-related learning activities when they had to use technologies associated with occupational areas (e.g. CAD, Office software). Fewer lecturers referred to activities using social networking websites or creating their own content (e.g. using presentations and videos).

Training needs and recommendations

Of the 364 answers, 300 (n = 64 missing or not evaluable) could be analysed. The lead author formed categories in an iterative process, based deductively on the question, and based inductively on the responses to Section D. To measure the reliability of the categorical scales, one rater coded them independently. As part of the content analysis of the data, a total of 451 codes were assigned in six categories and corresponding subcategories (see Table 6). The Brennan and Prediger (1981) coefficient is considered substantial, with an average $k = 0.72$.

Table 6: Categories of recommendations for training in order to improve digital competence

CATEGORY		EXAMPLE	N	KAPPA
1.	Content for training		223	0.75
1.1	Overview of digital technologies and their functionalities		136	0.77
	Standard digital technology	How to set up a projector and a laptop; how to use a smart board; setting up work documents in Microsoft Word and Excel; computer or ICT training	62	0.81
	Advanced digital technologies (for industry)	How to use ... the PLC program or a drawing program such as AutoCAD	12	0.81
	Teaching and learning technologies	Moodle	24	0.81
1.2	Digital content creation	How to record audio on slides; how to record videos to enhance teaching; how to do tests, questionnaires and crossword puzzles online	25	0.89
1.3	Pedagogic strategies or approaches to technology integration	How to manage a class and create proper assessments (using analysis grids online)	62	0.60

CATEGORY		EXAMPLE	N	KAPPA
2.	Organisation of a training session		69	0.63
	Settings and activities	Easy to understand; step-by-step indication; practical examples that are possible in reality	43	0.60
	Resources and infrastructure	More resources and equipment, with the respective training	18	0.54
	Organisation and support	Subject experts	8	0.70
3.	Other		173	0.70
	Professional development and engagement	... ALL teacher training programmes, including digital-related courses; continuous training; more time has to be reserved for training	108	0.62
	Resources and infrastructure at colleges	First, we need access to Wi-Fi; ... many lecturers do not even have a printer, never mind fancy technology!	60	0.78

Since the results regarding the design of further training are wide-ranging, the following section focuses primarily on important findings.

Training content (223 codes)

Regarding the needs and recommendations in respect of training content development, it became apparent that a training session should provide an overview of a variety of the latest technologies and their functionalities (136 codes). This includes standard technologies ranging from digital devices (20 codes), such as a digital whiteboard, and digital tools (27 codes), such as Office and presentation software and video-meeting apps, to advanced technologies (12 codes), such as robotics, CAD or simulation. There is a noticeable difference between the clusters. Whereas members of Cluster 1 had only a vague notion of what they needed, lecturers in Cluster 2 and 3 mentioned advanced technologies, for example a programmable logic controller (PLC), 4IR technologies, modelling and simulation, robotics or CAD.

Lecturers in all the clusters (24 codes) referred to technologies that enhanced their teaching and students' learning in general (e.g. Learning Management Systems) and technology that can be used effectively in the classroom in relation to their respective subjects (e.g. virtual media for language). The availability and usability of technologies for both lecturers and students were also of concern (n = 6). Moreover, the results showed that lecturers also need basic ICT training (15 codes):

Ensure that teachers are competent in basic computer work before trying to convert them to digital teaching. Many lecturers are forced to go over to digital

platforms but are not even comfortable with basic computer functions (male, 30–39 years, HADS, 3, 56).

Some lecturers showed a clear interest in improving their knowledge and skills in order to create engaging and interactive digital content (25 codes) that enhances teaching and learning processes. The selection, creation and modification of video resources (14 codes) were the most common among all the mentions of digital content creation included in this study, followed by the preparation of interesting and engaging presentations. The need for video content creation could be linked to the students' demands for training in video in order to be able to use these technologies (cf Denhere & Moloi, 2021b:233). Other less frequently mentioned technology resources were the development of quizzes, the use of e-books, generating QR codes, and the use of social media for learning and collaboration. Needs regarding digital content creation were mentioned less frequently by lecturers in Clusters 1 and 3 than members in Cluster 2.

In all three groups, the participants gave high priority to training in pedagogic strategies or approaches to technology integration (62 codes), that is, which pedagogic strategies or approaches should be chosen for a specific learning outcome, the methods and concepts of online teaching and learning, and the combination of tools to make education more engaging in order to enhance the student learning experience. Fewer lecturers were interested in using technologies for evaluation purposes. Apart from most lecturers who did not specify the subject, in the study it was found that the use of technology pertains to only a few subjects: language teaching and learning, and Mathematics. For example:

Basic and advanced computer training not only in using the Microsoft package but integrating it into the teaching of a subject-specific area Using technology in the English classroom in a purposeful way, for example (female, 50–59 years, HADS, 3, 69).

How to make use of the available technology in the classroom to enhance your teaching (male, 60 years or more, BUS,1, 20).

Organisation/course design (69 codes)

The requirements for the organisation of training include the demands for an integrated and multi-modal approach, problem orientation, or work with real cases and best practices. Among the participants, most preferred opportunities to participate in activities. One lecturer responded:

I would recommend ongoing skill[s] training [with] digital developments to ensure skills are up to date and relevant. Short courses that will provide the necessary exposure, and build the confidence of staff to explore, practise and make use of these technologies within a lesson (female, 50–59 years, STEM/HADS, 2, 105).

The lecturers' requirement for training is also reflected in inclusive training oriented towards target groups. Expert guidance, however, is mentioned by only two participants. Whereas some participants preferred in-house training to be developed, others required better technical equipment and better infrastructure to be installed at the training venues.

Professional development and engagement (108 codes)

The analysis of the results showed that there is an awareness among the lecturers of the need to be in step with the digital evolution and acquire competences for the use of digital technologies in the classroom (56 codes). It is striking that most of those who stressed the importance of digital competencies and their development belong to Clusters 2 and 3. They also argued that the development of digital competencies must be compulsory at all levels of teacher education. In addition, they stressed giving a high level of priority to a lifelong learning mentality and indicated a strong need for permanent training courses to keep up to date with the latest technologies and innovative methods. Some even promoted self-regulated learning for TVET lecturers, as clearly reflected in the following responses:

I would definitely recommend that ALL teacher training programmes include digital-related courses. ... I am a great supporter of continuous lifelong learning and hence would even recommend short courses that can serve to upskill our staff all the time (female, 50–59 years, HADS/STEM/BUS, 2, 9).

I ... recommend that we ... equip ourselves with technology, become advanced and implement it[,] as the world is becoming digitalised (female, 40–49 years, HADS, 2, 136).

Resources and infrastructure at colleges (60 codes)

Even if not explicitly covered in the survey, many participants referred to the poor infrastructure and resources at their colleges. The lecturers complained that their colleges were not equipped with a substantial amount of technology to make learning more effective. Limited Internet and Wi-Fi access is a common example of the problems. One lecturer commented:

Firstly, we need access to Wi-Fi. At our campus many lecturers do not even have a printer, never mind fancy technology! (female, 60 years or more, STEM, 1, 34).

Apart from needing the classroom to be well equipped with digital technologies, some participants require more laboratories – in particular those teaching information technology (IT). Often, the participants referred to having less or no technology use in the classroom or to limited access to technologies at the colleges. These findings align with the requirements of students in TVET colleges to have access to the latest MS Office applications and to improved infrastructure, such as reliable Internet/Wi-Fi and electric sockets to connect electronic devices (Denhere & Moloi, 2021b:233).

Discussion and implications

The purpose of this needs analysis was to identify the in-service TVET lecturers' requirements in order to design a training programme that includes the development of knowledge and skills for digital teaching and learning at TVET colleges in South Africa. Owing to the increasing number of digital processes in society and the world of work, the development of digital competence in TVET has become more relevant. On this point, lecturers play a key role in developing students' digital competence through the integration of technologies in the classroom. Therefore, in the study, the TVET lecturers' self-assessed knowledge of digital technology was measured by using the TPACK framework.

The results obtained show that lecturers at South African TVET colleges value their professional capacity in teaching, and in teaching with digital technologies, but have a continuing need to develop deep knowledge, understanding and application of technologies and their use in educational environments. The findings are consistent with current international research, suggesting that educational staff need more courses aimed at professional development, especially in order to develop their use of the TPACK framework (OECD, 2019; Redmond & Lock, 2019).

This study also provides a first insight into the techniques of integrating technology into TVET lecturers' classrooms. Considering the fact that lecturers must be able to integrate digital technologies effectively, the results suggest that the use of technology in the classroom is far from being an innovation in teaching practices that helps students to be able to use technology in productive ways and prepare them both for work and for participation in society (cf DCDT, 2021). In fact, in the main, the lecturers made only 'basic' use of digital technologies. However, they did implement technologies for teacher-centred purposes, such as preparing content and presenting information. Most lecturers tended not to use technology in a student-centred manner, such as engaging students in creating digital artefacts, in problem-solving and in critical thinking (e.g. using simulation). This is because the TVET lecturers felt that they were not sufficiently equipped with the required knowledge and skills to use digital technologies in the classroom or even 'appropriate' tools to exercise digital-related competence in teaching. These findings are in line with previous studies (Tondeur et al., 2017) which indicate that teachers employ technologies primarily in structured learning rather than to encourage active student engagement.

The results point to various needs for further training, stemming from basic computer skills to effective subject-specific technology integration (e.g. with regard to languages and Mathematics). The predominant needs that the lecturers expressed were competencies in standard digital technology, particularly MS Office and presentation software. These findings correspond to the students' training needs for computer skills identified in a qualitative study on the technology, technological skills and curriculum needs of students at South African public TVET colleges (Denhere & Moloji, 2021b).

However, in comparing these findings with the lecturers' self-perceived needs for pedagogical strategies to integrate technology into the classroom effectively, training must involve more than the development of basic digital skills: it must also offer preparation enhanced by the creation of opportunities for lecturers to experience the technology in practical-application scenarios. To increase the use of technology in teaching and learning, TVET lecturers need to be well informed about the value of technology and what contributes to the effective use of technology in learner-centred learning. In this study, it was also observed that the lecturers require practically oriented training programmes which offer activities that approximate real-world teaching contexts. In such programmes, the participants will be involved in the creation of educational content and in the design, application and evaluation of teaching concepts with technologies in real classroom settings. Allocating training opportunities, offering different levels of training, and forming practice groups should be instituted to help TVET lecturers cope with the multifaceted needs and the different levels of expertise. In particular, these measures should favour those lecturers with lower educational levels and those who seldom participate in training. As digital technology changes both unpredictably and at a rapid pace, TVET lecturers must continually acquire and update their technology-related skills through lifelong learning. The initial step is for TVET college authorities and all stakeholders involved in capacity-building programmes to identify the specific needs annually. In addition to self-assessed skill levels, indicators such as peer assessment, current technology use and integration, lecturer beliefs, the availability of resources, the specific needs and wants, and lecturer backgrounds should be included in a needs assessment.

Even if fewer participants mentioned collaboration and exchanges with other lecturers, in previous studies it has been argued that, apart from an effective form of training, teacher collaboration is a predictor of the daily integration of digital media into the classroom (Drossel, Eickelmann & Gerick, 2017). Therefore, lecturers could share best practices for technology integration and lesson plans among their colleagues, and a lecturer learning community should be instituted. Its *modus operandi* may include online forums, video conferencing, social networks, or software for collaborative learning.

The quantitative results indicate that there is little potential for the optimisation of the consecutive and in-service training of lecturers. The results also indicate a need for further training among older lecturers who do not possess consecutive or concurrent degrees, for the use of technology on the whole, and for the use of technology in the pedagogical context in particular.

The results of this study also show that a great need exists for higher education institutions to embed digital pedagogy in pre-service teacher education in order to prepare future lecturers for 21st-century classrooms. Consequently, curriculum adjustments would be required for both South African public TVET colleges and the training of TVET lecturers.

Limitations and future research

In this study, data were collected using an online self-report questionnaire. The approach used to measure the lecturers' technology-related knowledge and skills via self-assessment (Schmidt et al., 2009) offers an efficient means of collecting comparatively large amounts of data. However, self-reports present methodological issues that may threaten their internal validity. For example, there is a general tendency to give desirable answers in all self-reports (e.g. socially desirable responding). Furthermore, self-evaluated knowledge is relative to the extent of a persons' knowledge. In previous studies, it has been argued that low-skilled people fail to recognise their own lack of competence and tend to overestimate their knowledge and skill level (Dunning, 2011). In this regard, the measurement of knowledge in the TPACK domains may be limited by the ability and expertise of the TVET lecturers surveyed in this study to self-assess their knowledge across the items appropriately and not by them possessing the confidence to integrate technology (cf Krauskopf & Forssell, 2018). It is also likely that the participants overrate their own skill levels because they link the concept of digital competence to basic technical skills. For instance, the qualitative findings in this study show that the use of technology by lecturers is often limited to videos and presentation slides for demonstration purposes. At the same time, the lecturers perceived a need for their own digital competence to be developed.

In addition, the medium of the online survey could have introduced some self-selectivity to the extent that a few individuals not interested in digital technology, or those who do not have access to the Internet, took part in the first place. The data material of the open-ended questions in Section D of the form for the categorisation of the training needs may be a further limitation. The reason for choosing open-ended questions for the survey was to avoid any preconceived ideas and to obtain a more detailed picture of the lecturers' technology use and needs in respect of training. Yet, most of the answers were very short: some answers often consisted of one or two words only. Even if it were possible to detect some recurring ideas and general patterns, it was not always clear whether a term belonged to the category training content, training design, or resources and infrastructure at a college (e.g. 'technology'). The mixed-methods approach which was used to help critically appraise and synthesise the high level of self-assessment regarding technology use means that the evidence is not observable when viewing results alone from the TPACK self-assessment. Instead, the results must be interpreted in relation to context.

Since the sample size was lower than expected, it is difficult to detect significant differences in some instances. Only 366 of all the in-service lecturers at South African TVET colleges participated in this study; hence the sample is not representative of the total number of TVET lecturers. Because the sample is heterogeneous overall, it would be interesting to look at subgroups in more detail in the context of design-based research. Even if some lecturers considered the technology available to them as being inadequate, it was not possible with this survey to explain fully whether a lack of appropriate infrastructure and a lack of appropriate material resources may be barriers to technology integration, or if lecturers are less likely to use technologies only at the individual level. To gain insight into the lecturers' individual competence

levels, performance-based measurement in addition to the analysis of lesson plans, video-recorded lessons or classroom observations would increase external validity. A longitudinal study could be conducted in order to investigate how the availability and use of technology in TVET change over time. Future research may also consider additional factors such as students' attitude in respect of technology and whether they perceive it as being useful, in addition to the modes through which they engage with specific technologies. Furthermore, examining the effects of these factors on students' academic achievement is crucial.

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REFERENCES

- Berliner, DC. 2004. Expert teachers: Their characteristics, development and accomplishments. *Bulletin of Science, Technology & Society*, 24(3):200–212.
- Brennan, RL & Prediger, DJ. 1981. Coefficient Kappa: Some uses, misuses, and alternatives. *Educational and Psychological Measurement*, 41(3):687–699.
- Brislin, RW. 1970. Back-translation for cross-cultural research. *Journal of Cross-Cultural Psychology*, 1(3):185–216.
- Chai, CS, Koh, JHL & Tsai, CC. 2010. Facilitating preservice teachers' development of technological, pedagogical, and content knowledge (TPACK). *Journal of Educational Technology & Society*, 13(4):63–73.
- Charrad, M, Ghazzali, N, Boiteau, V & Niknafs, A. 2014. An R package for determining the relevant number of clusters in a data set. *Journal of Statistical Software*, 61(6):1–36. Available at: <<http://doi.org/10.18637/jss.v061.i06>>.
- Czerniewicz, L & Brown, C. 2013. The habitus of digital 'strangers' in higher education. *Journal of Educational Technology*, 44(1):44–53. Available at: <<http://doi.org/10.1111/j.1467-8535.2012.01281.x>>.
- DCDT (Department of Communications and Digital Technologies). 2020. *National Digital and Future Skills Strategy South Africa*. Available at: <http://www.gov.za/sites/default/files/gcis_document/201610/40325gon1212.pdf>. [Accessed 8 February 2023]
- DCDT (Department of Communications and Digital Technologies). 2021. *Implementation Programme for the National Digital and Future Skills Strategy of South Africa – Decent Jobs for Youth*. Available at: <http://www.gov.za/sites/default/files/gcis_document/202203/digital-and-future-skillsimplementation-programmefinal.pdf>. [Accessed 8 February 2023]
- Denhere, V & Moloi, T. 2021a. Readiness of public TVET for the Fourth Industrial Revolution: The case of South Africa. *Innovation of Vocational Technology Education*, 17(1):37–51.

- DCDT (Department of Communications and Digital Technologies). 2021. Implementation programme for the National Digital and Future Skills Strategy of South Africa – Decent jobs for youth. Available: http://www.gov.za/sites/default/files/gcis_document/202203/digital-and-future-skillsimplementation-programmefinal.pdf [Accessed: 8 February 2023].
- Denhere, V & Moloi, T. 2021a. Readiness of public TVET for the Fourth Industrial Revolution: The case of South Africa. *Innovation of Vocational Technology Education*, 17(1):37–51.
- Denhere, V & Moloi, T. 2021b. Technologies, technological skills and curriculum needs for South African public TVET college students for relevance in the 4IR era. *Journal of African Education*, 2(3):223–242.
- DHET (Department of Higher Education and Training). 2013. *Policy on Professional Qualifications for Lecturers in Technical and Vocational Education and Training*. Available at: <http://www.dhet.gov.za/Gazette/Policy%20on%20professional%20qualifications%20for%20lecturers%20in%20technical%20and%20vocational%20education%20and%20training.pdf>. [Accessed 8 February 2023]
- DHET (Department of Higher Education and Training). 2022. *Report on Skills Supply and Demand in South Africa*. Available at: <http://www.dhet.gov.za/Planning%20Monitoring%20and%20Evaluation%20Coordination/Report%20on%20Skills%20Supply%20and%20Demand%20in%20South%20Africa%20-%202022%20%281%29.pdf>. [Accessed 8 February 2023]
- Djukic, GP. 2022. Digital inclusion for vulnerable groups and transformation: A comparative case study. In N Baporikar (Ed). *Handbook of research on global institutional roles for inclusive development*. IGI Global, 19–20.
- Drossel, K, Eickelmann, B & Gerick, J. 2017. Predictors of teachers' use of ICT in school – the relevance of school characteristics, teachers' attitudes and teacher collaboration. *Education and Information Technologies*, 22(2):551–573. Available at: <http://doi.org/10.1007/s10639-016-9476-y>.
- Dunning, D. 2011. The Dunning–Kruger effect: On being ignorant of one's own ignorance. *Advances in Experimental Social Psychology*, 44:247–296.
- Ertmer, PA et al. 2012. Teacher beliefs and technology integration practices: A critical relationship. *Computers & Education*, 59(2):423–435. Available at: <http://doi.org/10.1016/j.compedu.2012.02.001>.
- EU (European Union). 2018. *Council recommendation of 22 May 2018 on key competences for lifelong learning text with EEA relevance*. Available at: [http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604\(01\)&rid=7](http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01)&rid=7). [Accessed 8 February 2023]
- Ferrari, A, Punie, Y & Redecker, C. 2012. Understanding digital competence in the 21st century: An analysis of current frameworks. In D Hutchison, T Kanade, J Kittler, JM Kleinberg, F Mattern & JC Mitchell et al. (Eds). *21st century learning for 21st century skills*, Bd. 7563. Berlin/ Heidelberg: Springer (Lecture Notes in Computer Science), 79–92.
- Gretch, A & Camilleri, A. 2020. *The digitization of TVET and skills systems*. Geneva: International Labour Organization. Available at: <http://search.ebscohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=3136579>. [Accessed 8 February 2023]
- Guggemos, J & Seufert, S. 2021. Teaching with and teaching about technology – evidence for professional development of in-service teachers. *Computers in Human Behavior*, 115. Available at <http://doi.org/10.1016/j.chb.2020.106613>.

- Guthrie, H, Harris, R, Simons, M & Karmel, T. 2009. Teaching for technical and vocational education and training (TVET). In J Saha & AG Dworkin (Eds). *International handbook of research on teachers and teaching*. New York: Springer.
- Huberman, M. 1989. The professional life cycle of teachers. *Teacher College Records*, 91:31–57.
- Kimmons, R & Hall, C. 2018. How useful are our models? Pre-service and practicing teacher evaluations of technology integration models. *TechTrends*, 62(1):29–36. Available at <<http://doi.org/10.1007/s11528-017-0227-8>>.
- Koehler, MJ et al. 2014. The technological pedagogical content knowledge framework. In JM Spector, MD Merrill, J Elen & MJ Bishop, MJ (Eds). *Handbook of research on educational communications and technology*. New York: Springer, 101–111.
- Krauskopf, K & Forssell, K. 2018. When knowing is believing: A multi-trait analysis of self-reported TPCK. *Journal of Computer Assisted Learning*, 34(5):482–491. <http://doi.org/10.1111/jcal.12253>.
- Kuhn, T. 1977. *The essential tension*. Chicago: Chicago University Press.
- Langthaler, M & Bazafkan, H. 2020. Digitalization, education and skills development in the Global South: An assessment of the debate with a focus on Sub-Saharan Africa. ÖFSE Briefing Paper, No. 28, Austrian Foundation for Development Research (ÖFSE). Vienna. Available at: <<http://www.econstor.eu/bitstream/10419/228970/1/1743471084.pdf>>. [Accessed 8 February 2023]
- Magwentshu, N, Rajagopaul, A, Chui, M & Singh, A. 2019. *The future of work in South Africa: Digitisation, productivity and job creation*. McKinsey and Company. Available at: <<http://www.mckinsey.com/-/media/mckinsey/featured%20insights/middle%20east%20and%20africa/the%20future%20of%20work%20in%20south%20africa%20digitisation%20productivity%20and%20job%20creation/the-future-of-work-in-south-africa.pdf>>. [Accessed 21 April 2023]
- Makgato, M. 2020. STEM for sustainable skills for the Fourth Industrial Revolution: Snapshot at some TVET colleges in South Africa. In GF Kehdinga (Ed). *Theorizing STEM education in the 21st century*. IntechOpen.
- Matli, W & Ngoepe, M. 2020. Capitalizing on digital literacy skills for capacity development of people who are not in education, employment or training in South Africa. *African Journal of Science, Technology, Innovation and Development*, 12(2):129–139. Available at: <<http://doi.org/10.1080/20421338.2019.1624008>>.
- Mayring, P. 2015. *Qualitative Inhaltsanalyse: Grundlagen und Techniken* (11 ed). Basel: Beltz Verlag.
- Mbanga, N & Mtembu, VN. 2020. Digital learning: Perceptions of lecturers at a technical vocational educational and training college. *South African Journal of Higher Education*, 34(4):155–173. Available at: <<http://doi.org/10.20853/34-4-3656>>.
- Mishra, P & Koehler, MJ. 2006. Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6):1017–1054.
- Naiker, V & Makgato, M. 2018. The integration of ICT in TVET college classrooms: A case in automotive repair and maintenance teaching. *International Journal of Educational Sciences*, 20(1–3). Available at: <<http://doi.org/10.31901/24566322.2018/20.1-3.04>>.
- Naudé, W. 2017. *Entrepreneurship, education and the Fourth Industrial Revolution in Africa*. IZA Discussion Papers 10855. Institute of Labor Economics (IZA).

- Ngubane-Mokiwa, S & Khoza, SB. 2016. Lecturers' experiences of teaching STEM to students with disabilities. *Journal of Learning for Development*, 3(1):40–54. Available at: <<http://doi.org/10.56059/jl4d.v3i1.125>>.
- OECD (Organisation for Economic Co-operation and Development). 2019. *Skills outlook 2019*. OECD. Available at: <<http://www.oecd-ilibrary.org/docserver/df80bc12-en.pdf?expires=1675789882&id=id&accname=ocid77015704&checksum=B6D03C5A4858BBBAFAF9D83CC84F4F059>>. [Accessed 8 February 2023]
- Redecker, C. 2017. *European framework for the digital competence of educators*. DigComEdu.
- Redmond, P & Lock, J. 2019. Secondary pre-service teachers' perceptions of technological pedagogical content knowledge (TPACK): What do they really think? *AJET*, 35(3):45–54. Available at: <<http://doi.org/10.14742/ajet.4214>>.
- Sailer, M et al. 2021. Technology-related teaching skills and attitudes: Validation of a scenario-based self-assessment instrument for teachers. *Computers in Human Behavior*, 115:1–12. Available at: <<http://doi.org/10.1016/j.chb.2020.106625>>.
- Schmidt, D et al. 2009. Technological pedagogical content knowledge (TPACK): The development and validation of an assessment instrument for preservice teachers. *Journal of Research on Technology in Education*, 42(2):123–149.
- Schmitz, M-L et al. 2022. When barriers are not an issue: Tracing the relationship between hindering factors and technology use in secondary schools across Europe. *Computers & Education*, 179. Available at: <104411. <http://doi.org/10.1016/j.compedu.2021.104411>>.
- Schwarzer, R & Jerusalem, M. 2002. *Das Konzept der Selbstwirksamkeit*. In M Jerusalem & D Hopf (Eds). *Selbstwirksamkeit und Motivationsprozesse in Bildungsinstitutionen*. Weinheim: Beltz, 28–53.
- Seufert, S, Guggemos, J, Tarantini, E & Schumann, S. 2019. Professionelle Kompetenzen von Lehrpersonen im Kontext des digitalen Wandels Entwicklung eines Rahmenkonzepts und Validierung in der kaufmännischen Domäne. *Zeitschrift für Berufs- und Wirtschaftspädagogik*, 115(2):312–339.
- Sherman, K & Howard, SK. 2012. Teachers' beliefs about first- and second-order barriers to ICT integration: Preliminary findings from a South African study. Conference proceedings, *23rd International Conference of Society for Information Technology and Teacher Education*. Charlottesville, VA, 2098–2105.
- Shulman, LS. 1987. Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1):1–22.
- SSA (Statistics South Africa). 2022. *Quarterly labour force survey*. Available at: <<http://www.statssa.gov.za/publications/P0211/P02112ndQuarter2022.pdf>>. [Accessed 8 February 2023]
- Stroot, S et al. 1998. *Peer assistance and review guidebook*. Columbus, OH: Ohio Department of Education.
- Stroot, S., Keil, V, Stedman, P, Lohr, L, Faust, R, Schincariol-Randall, L, Sullivan, A, Czerniak, G, Kuchcinski, J, Orel, N & Richter, M. 1998. Peer assistance and review guidebook. Columbus, OH: Ohio Department of Education., S et al. 1998. *Peer resistance and review guide*. Columbus, OH: Ohio Department of Education

- Teis, NJP & Els, CJ. 2021. Knowledge, competencies and dispositions of lecturers in Technical Engineering in the context of advancing 4IR technologies. *Journal of Vocational, Adult and Continuing Education and Training*, 4(1):26. Available at: <<http://doi.org/10.14426/jovacet.v4i1.186>>.
- Tondeur, J, Petko, D, Christenson, R, Drossel, K, Starkey, L, Knezek, G & Schmidt-Crawford, DA. 2021. Quality criteria for conceptual technology integration models in education: Bridging research and practice. *Educational Technology Research and Development*, 69(4):2187–2208. Available at: <<http://doi.org/10.1007/s11423-020-09911-0>>.
- Tondeur, J, Scherer, R, Siddiq, F & Baran, E. 2017. A comprehensive investigation of TPACK within pre-service teachers' ICT profiles: Mind the gap! *Australasian Journal of Educational Technology*, 33(3):46–60. Available at: <<http://doi.org/10.14742/ajet.3504>>.
- Twinomurinzi, H, Msweli, NT & Phukubje, P. 2020. *Digital technologies and digital skills in organisations and government in SA*. Pretoria: NEMISA and Unisa Press. Available at: <<http://uir.unisa.ac.za/bitstream/handle/10500/27620/Digital%20Technologies%20and%20Digital%20Skills%20in%20Organisations%20and%20Government%20in%20SA.pdf?sequence=1&isAllowed=y>> [Accessed 8 February 2023] UNESCO (United Nations Educational, Scientific and Cultural Organization). 2018. *UNESCO ICT competency framework for teachers*.
- Zinn, B, Brändle, M, Pletz, C & Schaal, S. 2022. *Wie schätzen Lehramtsstudierende ihre digitalisierungsbezogenen Kompetenzen ein? Die Hochschullehre*, 8:156–171. Available at: <<http://doi.org/10.3278/HSL2211W>>.