Utilising ICT for classroom teaching and learning: Practices among South African teachers[1]

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ABSTRACT

This research considered South African primary school teachers' use of Information Communication and Technology (ICTs) in the domains of English First Additional Language, mathematics, and natural sciences. Utilising the Technological Pedagogical Content Knowledge (TPACK) framework, the study explored what ICTs are being used for assessment purposes and how ICTs are being used. Employing a mixed-method approach within a pragmatist paradigm, a survey designed by the researchers was administered to teachers with a minimum of five years of experience. Quantitative analysis of closed-ended questions revealed that commonly used ICT tools included personal computers, the internet, intranet, and mobile devices, whereas outdated technologies like CDs and DVDs were seldom utilised. Surprisingly, newer ICTs, such as WhatsApp, were not as frequently employed as anticipated. Qualitative insights demonstrated that teachers harnessed ICTs for various functions, including formative and summative assessments, multimedia learning, personalised learning, resource discovery, engagement with educational platforms, and document handling. The findings revealed that social impact on behavioural intention was the only significant effect. Highlighting the critical role of peer and institutional support structures to encourage ICT adoption. Additionally, addressing resource and infrastructure gaps, alongside targeted training and capacity development, is crucial for enabling effective ICT-based assessment in South African primary schools.

Keywords: ICT, assessment, digital competency, technology, TPACK

INTRODUCTION

While Information and Communication Technology (ICT) holds considerable promise for enhancing teaching and learning (T&L), particularly in assessment, its integration into classroom practice remains uneven, especially in South African primary schools. This article investigates how teachers employ ICT to support teaching and learning, with a specific focus on assessment, and explores the reasons for this inconsistent use. We foreground practical

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factors such as contextual limitations, teachers' competencies, and access to resources that shape teachers' decisions to integrate ICT. By doing so, we move beyond generic discussions of ICT's potential to provide a more nuanced understanding of how ICT is being used and could be better leveraged to strengthen assessment practices in South African classrooms.

The transformative role of ICT in education is acknowledged globally and more recently in South Africa (Dube et al., 2018; Gunu et al., 2022; Koohang et al., 2023). The adoption of ICTs has not only enhanced human activities worldwide but has also significantly influenced assessment methodologies in classrooms (Khan, 2018; Koohang et al., 2023). One of the promising benefits of incorporating ICTs in T&L and assessment, is the active engagement and motivation of learners. Recognising the diverse learning needs, ICTs can accommodate various learning styles, including visual and auditory learning (Bang & Luft, 2013; Semerci & Aydin, 2018). Learning Management Systems (LMS), such as Canvas, Google Classroom, Moodle, and Blackboard, have become instrumental in assessment activities, offering tools for content uploading, tracking, blogs, and wikis (Chan et al., 2018; Kaup et al., 2020). In the context of 21st century skills, formative assessment plays a crucial role in nurturing competencies such as critical thinking, creativity, collaboration, communication, and digital literacy (Combrinck & Van Vollenhoven, 2020; Mdlalose et al., 2022). Constructive criticism, closely tied to assessment in education, supports learners' growth and development (Aslam & Khan, 2020). Formative assessment serves as an innovative and effective approach to evaluating learners' progress in acquiring the competencies needed for success in the modern world. South Africa, currently at the cusp of leveraging ICTs in education, has the potential to redefine evaluation methods and transform T&L in the 21st century (Giovannella & Passarelli, 2020; Lawrence & Tar, 2018; Mhlanga & Moloi, 2020).

MOTIVATION FOR STUDY

This study investigates the complexities behind which ICTs South African teachers are using and how they are using them, emphasising that merely providing ICT tools to teachers is insufficient (Mhlanga & Moloi, 2020). The COVID-19 pandemic has underscored the urgency of understanding and incorporating ICTs into education, especially for assessment purposes, as teachers navigate remote and online assessment (Mhlanga & Moloi, 2020). While existing literature highlights opportunities, challenges, and risks associated with reassessing assessment practices in the digital era (Cumhur & Çam, 2021; Sahu, 2020), the underdeveloped nature of assessment with ICT is noted (Timmis et al., 2016). Although research on ICT integration into T&L is extensive, the use of ICT specifically for classroom-based assessment remains underexplored, particularly in South African primary schools with limited resources. Most existing studies focus on how ICT supports general T&L processes, paying minimal attention to its role in assessment practices (Charteris et al., 2016; Timmis et al., 2016). Yet, effective assessment is pivotal for improving learner outcomes, and ICT offers transformative assessment possibilities, such as immediate feedback, multimodal engagement, and personalised learning. However, ICT benefits are often constrained by inadequate infrastructure, insufficient teacher skills, and persistent contextual barriers such as load shedding and socio-economic disparities (Ramafi, 2022; Visentin, 2020). This is consistent with the foundational work of Ertmer (1999), who distinguished between first-order (external, such as infrastructure) and second-order (internal, such as beliefs and attitudes) barriers to technology integration, both of which remain highly relevant in the South African

context. This study addresses this critical research gap by investigating how teachers' attitudes toward ICT, their competencies, and their contextual realities influence their use of technology for T&L and assessment purposes in South African primary schools.

The shift in teacher roles necessitates equipping teachers with the skills, attitudes, and knowledge required for effective ICT use in assessment (Rubach & Lazarides, 2021). Challenges in South African schools, including limited ICT infrastructure, learners' digital competencies, and external factors like load shedding and crime, hinder the implementation of the ICT curriculum (Ramafi, 2022). The importance of cultivating teachers' digital competencies is emphasised, but this can only be done if one first understands what ICTs teachers are using for assessment purposes and how they are using it. Investigating the 'what' is important, as teachers may have many ICTs available to them, but only use some of them, and the 'how' is important, as one can only improve teachers' ICT integration if one understands how they are currently using ICTs in their classrooms. We focussed on primary school teachers since it is well-known that they serve as the foundational stage of education, shaping the cognitive and social development of learners, laying the groundwork for lifelong learning, and influencing their academic trajectories in higher levels of schooling. This study focuses on English First Additional Language (EFAL), mathematics, and natural science classrooms, subjects identified as critical learning areas where effective assessment is key to improving learner achievement. This focus is justified by results from two major international large-scale assessments: the Progress in International Reading Literacy Study (PIRLS 2021) and the Trends in International Mathematics and Science Study (TIMSS 2019), both of which report persistently low performance among South African learners in reading literacy, mathematics, and science (Department of Basic Education [DBE], 2023; Reddy et al., 2022). These findings underscore the urgent need to strengthen assessment practices in these subjects. In this context, ICT-based assessment holds particular promise for providing timely feedback, promoting learner engagement, and enhancing overall assessment quality. By concentrating on EFAL, mathematics, and natural science, the study remains highly relevant and strategically aligned with national priorities and international benchmarks, targeting areas where ICT integration could yield the most significant educational impact.

The specific research questions (RQ) were as follows:

RQ1: What available ICTs do South African teachers use in their classrooms for primary school (Grades 1 – 7) assessment in EFAL, mathematics and natural science classrooms for assessment purposes?

RQ2: How do South African teachers use ICTs for assessment purposes in their classrooms for primary school (Grades 1 – 7) assessment in EFAL, mathematics and natural science classrooms?

LITERATURE REVIEW

Assessment serves to gauge learners' readiness, progress, and educational needs, fostering observable and quantifiable learning (Alawajee & Almutairi, 2022; Florjančič, 2022). Seminal contributions by Black and Wiliam (1998) on formative assessment highlight the importance of feedback in improving learner outcomes, a principle that underpins many ICT-based assessment tools used today. As the education environment evolves, the integration of ICT in assessment demands new skills and considerations (Charteris et al., 2016). The global shift

to a digital paradigm has emphasised the importance of e-assessment (AlTameemy et al., 2020; Hadjerrouit & Nnagbo, 2022), impacting education worldwide. E-assessment offers advantages such as multimedia integration, global accessibility, convenience, immediate feedback, scalability, and customisability (Almuhanna, 2023; AlTameemy et al., 2020; Jabsheh, 2020). However, to be able to implement e-assessment, teachers need to use ICTs (the 'what'), but not only use them, but use them optimally (the 'how'). E-assessment has been a topic of global interest; for example, in Indonesia, it was found that e-assessment, facilitated by assessment apps, enhances objectivity, reduces biases, and promotes cost efficiency (Astalini et al., 2019; Gong, 2018). Web 2.0 technologies in Cameroon foster interactive learning experiences, providing diverse resources and facilitating engagement (Haji et al., 2017). Google Classroom proves effective in higher education, enhancing learner engagement through collaborative learning methods (Al-Maroof & Al-Emran, 2018; Martin, 2021). Over the last few years, South Africa has experienced a transition to computer-based assessments, offering real-time scoring, rapid feedback, and assessment of 21st century skills (Adelabu & Alex, 2023; Molnár & Csapó, 2019). A shift from traditional paper-based assessments to computer-aided assessments has prompted teachers to reassess their T&L and assessment strategies. More teachers are now using computer-based assessments to evaluate learners' competencies. Numerous organisations have adopted this approach to assess candidates' performance, competencies, and skills across various fields (Alek et al., 2020).

In the context of South African primary schools, Hove and Grobbelaar (2020) conducted a study where the use of ICTs in South African primary schools was summarised, and they found that using ICTs for learner assessment ranked 5th after: 1) reporting system, 2) learner enrolment, 3) administration and school management, and 4) enrolment management system. However, the article by Hove and Grobbelaar (2020) was submitted to the journal on 18 April 2019, before the first case of COVID appeared in South Africa (which was on 5 March 2020; Modisenyane et al., 2022), as such it didn't include the effect of COVID-19 on the use of ICTs in the educational sector. Amid the COVID-19 pandemic, Ahmed and Opoku (2022) found that online assessment became prevalent in South African educational institutions due to the transition to online T&L, necessitating changes in assessment methods to suit the digital context. Online assessments have been found to be beneficial for teachers in terms of reducing the time required for preparation and management of the assessment period (Dabhi et al., 2022). This efficiency gain aligns with the broader trend of utilising digital tools in assessment, showcasing how teachers are increasingly using ICT to streamline their assessment strategies. The 'what' involves the adoption of online assessments, while the 'how' pertains to the notable reduction in the time needed for assessment preparation and management.

One of the advantages associated with digital assessment is the potential to broaden the scope of measurement within an evaluation (Awang, 2021). The emergence of digital technology has enabled teachers to create assessments that can effectively evaluate multiple skills simultaneously. This development involves an evaluation that can assess learners' skills in areas requiring knowledge and cognitive processes that were previously challenging to evaluate. An illustrative example is an evaluation measuring a learner's proficiency in technical computing, decision-making ability, and aptitude for strategic planning, all of which can be effectively assessed using simulation exercises.

The integration of artificial intelligence (AI) technologies in assessment practices provides teachers with numerous opportunities to improve their methods of evaluating learners and creating more effective learning environments. AI-powered writing assistants (e.g., Grammarly, ProWritingAid, and Ginger) can automatically assess and grade learners' written assignments, evaluating different aspects such as word usage, grammar, and sentence structure. Automating the grading process not only increases efficiency for teachers but also promotes greater consistency and objectivity in the evaluation of assignments (Ramesh & Sanampudi, 2022). This technological advancement aligns with the broader trend of utilising digital tools in assessment, showcasing how teachers are increasingly incorporating ICT to enhance their assessment strategies. The "what" involves the integration of AI tools, specifically writing assistants, into the assessment process. The "how" relates to the automated evaluation of written assignments, streamlining the grading process and fostering consistency and objectivity among teachers.

THEORETICAL FRAMEWORK

The Technological Pedagogical Content Knowledge (TPACK) framework was used to guide the current study (Mishra & Koehler, 2006). The TPACK provides a lens to analyse how South African teachers can integrate their content knowledge (CK) in EFAL, mathematics, and natural science with their pedagogical knowledge (PK) and technological knowledge (TK) to select and use ICT tools for assessment purposes.

The TPACK theory argues that it is not knowledge of technology itself which is the basis of effective teaching and learning with technology but rather a specialist form of knowledge which arises when knowledge of technology is integrated with pedagogical knowledge and content knowledge (Saubern et al., 2020: 6).

The TPACK is still very relevant today and is used in many research articles; for example, in the year 2020, Saubern and colleagues wrote an editorial review of research using the TPACK framework published in the *Australasian Journal of Educational Technology* from 2015 to 2020 and found 22 publications in just this one journal alone 'in which the TPACK framework was used substantially as a theoretical or methodological base for research' (2020: 1). The reason for their focus on this specific journal was that, in 2017, this journal published what was believed to be the first-ever TPACK-themed journal special issue (Harris et al., 2017). More recent systematic reviews confirm ongoing importance of the TPACK; for example, Arifuddin et al. (2025) conducted a systematic review of TPACK research from 2019 to 2023, identifying self-efficacy, a comprehensive understanding of TPACK dimensions, the ability to analyse challenges in technology integration, and the development of a positive paradigm towards technology use as key trends. Their review emphasises that teacher professionalism and effective ICT use are strongly associated with TPACK competence, particularly in adapting to diverse classroom contexts. In terms of this research, how TPACK interlinks with the study is elaborated on in the conclusion section.

METHODOLOGY

The study employed a concurrent triangulation design within a mixed-methods research approach. The study was cross-sectional in nature, using a pragmatic approach that prioritises practicality and adaptability. Pragmatism supports a balanced assessment approach that acknowledges the importance of both quantitative and qualitative data in ICT-based

assessments. This approach is essential for obtaining a comprehensive understanding of learner performance (King, 2022). Non-probability purposive sampling was utilised, with the sample being chosen based on a set of shared common ICT knowledge and the requirements of the current study. The participants included primary school teachers teaching Grades 1 to 7 who have taught one of the following subjects for at least five years in South Africa: English First Additional Language (EFAL), mathematics or natural sciences. For this study, the research sample comprised 45 government schools located across 15 districts in the Gauteng Province, specifically within the Tshwane North education district. Schools were purposefully selected to ensure representation of rural, urban, and township contexts, allowing examination of diverse teaching environments and contexts. This sampling strategy allowed the researchers to explore how variations in ICT infrastructure, internet accessibility, and socio-economic conditions influence teachers' use of ICT for assessment purposes. It should be noted that 45 schools in the Gauteng province across 15 districts were considered, but only 25 schools participated. Two hundred teachers completed the survey, with the majority being female (42.0%), followed by male (40.5%), while a small percentage of respondents preferred not to disclose their gender (9.0%) or selected "other" (8.5%). Regarding age distribution, slightly over one-third of teachers (32.5%) fell within the age bracket of under 30 years, slightly below one-third of teachers (27.0%) were between the ages of 30 and 39 years old, approximately one-fifth (21.5%) of teachers were between the ages of 40 and 49 years old, whereas the remaining teachers (approximately one-fifth; 19.0%) were 50 years or older.

The grade distribution revealed that the highest proportion of teachers taught Grades 4 to 6 (36.5%, 46.5%, and 46.5% respectively), indicating a strong representation in the Intermediate Phase. Teachers from the Foundation Phase were also included, with 20.5% teaching Grade 1, 14% teaching Grade 2, and 17% teaching Grade 3, ensuring representation across the primary school spectrum. The majority of participants taught subjects and grades directly aligned with the study's objective of investigating ICT integration for assessment in EFAL, mathematics, and natural sciences. Although a small number of teachers taught grades beyond Grade 7, their responses were retained only where relevant to the primary school context.

For data collection, a self-developed questionnaire was distributed to participants via email. The instrument consisted of five sections and included 14 primary questions, many of which contained sub-items or multiple statements. For example, one item asked respondents to indicate their level of agreement with 27 statements related to ICT integration, using a five-point Likert scale. The questionnaire was originally designed to examine teachers' use of ICT for assessment purposes. It aimed to measure teachers' access to ICT at school, their actual usage for informal assessment and lesson planning during school hours, and the support environment influencing this use. However, qualitative responses indicated that teachers frequently described ICT use that extended beyond assessment to broader T&L practices. Given the interrelated nature of T&L and assessment, and the frequency with which both were referenced, this article focuses on ICT use in T&L, with a particular emphasis on assessment. The ICT tools included in the questionnaire were selected based on their widespread use in South African primary schools and their recommendation by the DBE (Padayachee, 2017). This list comprises commonly available hardware and software used to support both T&L and assessment. For the purposes of this article, however, only responses to items concerning

which ICT tools are being integrated and how they are used in T&L and assessment practices are analysed. This article is part of a broader study that investigated different facets of ICT integration for assessment purposes, but the results of 'why' teachers use the ICTs they use, and the results of the challenges experienced in ICT integration for assessment, are reported in two other separate papers due to the size of the overall project. The reliability of the questionnaire was determined by establishing that Cronbach's alpha values for the constructs were above 0.6. While a Cronbach's alpha of 0.70 is widely accepted as the minimum threshold for internal consistency, some scholars consider values as low as 0.60 acceptable (Jonker et al., 2024, citing sources from 2008 to 2021 to support this view). It is well-known that the Cronbach's alpha increases as the number of items on the construct increases, and, as expected, the constructs with many items were above 0.6; however, for those with only a few items, the Cronbach's alpha values were below 0.6. In the latter case, for constructs with few items, authors have suggested the consideration of inter-item correlations with values between 0.2 and 0.4 being optimum (Pallant, 2020; Robertson & Evans, 2020), which was the case for the constructs with few items and Cronbach's alpha coefficients below 0.6. Construct validity was assessed, encompassing both convergent and discriminant validity (Piedmont, 2014). Convergent validity requires that items loading on the same construct are significantly and strongly correlated, indicating that they measure the same underlying concept. In contrast, discriminant validity requires that items from different constructs are not as strongly correlated, confirming that the constructs are distinct from one another. Although all correlations are not presented here for brevity, the observed correlation patterns were consistent with these expectations, thereby supporting the construct validity of the questionnaire. The quantitative data (obtained via closed-ended questions) considered in this article were analysed using the Statistical Program for the Social Sciences (SPSS) version 28. The data analysis included descriptive statistics such as frequencies and percentages. For the qualitative data (obtained via open-ended questions) considered in this study, thematic analysis was used to analyse participant responses from Qual 3 ('How do you apply the assessment ICT tools mentioned above in a typical lesson?') and Qual 4 ('Is there anything else you would like to add about the use of ICT?'). Following Braun and Clarke's (2006) structured yet flexible approach, we systematically identified, analysed, and reported patterns (themes) within the data. The analysis followed six steps: (1) Familiarisation – the researcher read and re-read all responses to gain an in-depth understanding and noted preliminary ideas; (2) Generating initial codes – significant features relevant to the research questions were coded, including aspects such as interactive digital assessment tools, technical constraints, learner motivation, teacher adaptability, and infrastructure gaps; (3) Searching for themes – related codes were grouped into provisional themes, for example, responses on the practical classroom use of ICT were grouped under Integration of ICT in Daily Assessment; (4) Reviewing themes – themes were refined to ensure accuracy, coherence, and to eliminate redundancy; (5) Defining and naming themes – each theme was clearly delineated to reflect its scope and analytical focus; and (6) Producing the report – a detailed narrative was constructed, linking themes to the research objectives and illustrating findings with direct participant quotes. The final themes included: Formative Assessment through ICT, Contextual Barriers to ICT Use, and Teacher Confidence and Professional Support. These themes provide a contextualised understanding of how ICT is used for assessment in South African primary school classrooms.

To ensure ethical conduct, the research secured necessary permissions, including permission from the [name removed to ensure blind review] and clearance from the [name removed to ensure blind review]. Invitations to participate were extended voluntarily, with participants providing explicit consent. They received comprehensive information about the study's implications, ensuring a clear understanding, and no coercion was employed. All data was treated confidentially and anonymously.

RESULTS AND DISCUSSION

To address the 'what', respondents had to indicate the frequency of use of ICTs for assessment purposes in the classroom if the ICTs were available to them. The response options were 1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Often, and 5 = Not applicable. The latter option was included for those respondents who did not have the specific ICT listed in the survey in their classroom. Additionally, South African teachers are generally permitted to use ICTs in South African primary schools; however, the questionnaire did not explicitly investigate formal policy restrictions, and therefore, no detailed analysis is provided on whether teachers were formally authorised to use these ICTs in their classrooms. The responses are summarised in Table 1.

Table 1:

Frequency and Percentage Responses Relating to ICTs Usage for Assessment Purposes in the Classroom

ICT	Never	Rarely	Sometimes	Often	Not applicable
Personal Computer/Laptop	12 (6.0)	27 (13.5)	83 (41.5)	72 (36.0)	6 (3.0)
The Internet	7 (3.5)	22 (11.0)	70 (35.0)	97 (48.5)	4 (2.0)
Mobile Devices (e.g., cell phones or tablets)	8 (4.0)	23 (11.5)	58 (29.0)	107 (53.5)	4 (2.0)
Radio	104 (52.0)	31 (15.5)	32 (16.0)	17 (8.5)	16 (8.0)
Intranet (e.g., school network)	23 (11.5)	23 (11.5)	78 (39.0)	72 (36.0)	4 (2.0)
Television	135 (67.5)	12 (6.0)	15 (7.5)	19 (9.5)	19 (9.5)
CD ROM/DVDs	115 (57.5)	24 (12.0)	30 (15.0)	13 (6.5)	18 (9.0)
Scanner	98 (49.0)	38 (19.0)	41 (20.5)	15 (7.5)	8 (4.0)
Printer	61 (30.5)	41 (20.5)	53 (26.5)	43 (21.5)	2 (1.0)
E-Mail	58 (29.0)	41 (20.5)	48 (24.0)	47 (23.5)	6 (3.0)
Overhead Projector	118 (59.0)	24 (12.0)	37 (18.5)	14 (7.0)	7 (3.5)
Video Camera	103 (51.5)	24 (12.0)	39 (19.5)	22 (11.0)	12 (6.0)
Data Projector	132 (66.0)	18 (9.0)	18 (9.0)	15 (7.5)	17 (8.5)
Smart Board/Interactive Board	113 (56.5)	21 (10.5)	18 (9.0)	15 (7.5)	33 (16.5)
Document Camera/ Visualizer	135 (67.5)	11 (5.5)	15 (7.5)	10 (5.0)	29 (14.5)
Microsoft Word	68 (34.0)	30 (15.0)	45 (22.5)	51 (25.5)	6 (3.0)

Microsoft Excel	91 (45.5)	34 (17.0)	39 (19.5)	30 (15)	6 (3.0)
Microsoft PowerPoint	102 (51.0)	29 (14.5)	35 (17.5)	27 (13.5)	7 (3.5)
Facebook	143 (71.5)	12 (6.0)	16 (8.0)	21 (10.5)	8 (4.0)
Twitter	150 (75.0)	10 (5.0)	16 (8.0)	16 (8.0)	8 (4.0)
Skype, Microsoft Teams, Zoom, etc.	33 (16.5)	17 (8.5)	101 (50.5)	42 (21.0)	7 (3.5)
Instagram	154 (77.0)	14 (7.0)	8 (4.0)	13 (6.5)	11 (5.5)
WhatsApp Messenger	129 (64.5)	19 (9.5)	19 (9.5)	25 (12.5)	8 (4.0)
Video Conference	140 (70.0)	17 (8.5)	19 (9.5)	13 (6.5)	11 (5.5)
YouTube Videos	51 (25.5)	32 (16.0)	71 (35.5)	39 (19.5)	7 (3.5)
Explain Everything	79 (39.5)	10 (5.0)	20 (10.0)	30 (15.0)	61 (30.5)
Google Docs	120 (60.0)	15 (7.5)	20 (10.0)	20 (10.0)	25 (12.5)
Blogs	131 (65.5)	13 (6.5)	13 (6.5)	10 (5.0)	33 (16.5)
Learner Management System (LMS) (e.g., Edmodo, Moodle, Blackboard, etc.)	101 (50.5)	20 (10.0)	27 (13.5)	18 (9.0)	34 (17.0)
Drop Box	125 (62.5)	15 (7.5)	13 (6.5)	8 (4.0)	39 (19.5)
Note Sharing (e.g., Evernote, OneNote etc.)	129 (64.5)	14 (7.0)	12 (6.0)	8 (4.0)	37 (18.5)
Webinars	121 (60.5)	15 (7.5)	18 (9.0)	7 (3.5)	39 (19.5)
e-Portfolios	120 (60.0)	15 (7.5)	23 (11.5)	10 (5.0)	32 (16.0)

Examining the data presented in Table 1 sheds light on the nuanced patterns of ICT adoption among South African primary school teachers. Regarding the 'what' (RQ1), notably, a discernible trend emerges, showcasing a predilection for certain technologies over others. Personal computers, the internet, intranet (e.g., school network), and mobile devices exhibit higher frequencies in the 'sometimes' and 'often' categories, indicating their predominant use for assessment purposes. In contrast, more outdated ICT tools such as radio, television, scanners, and CDs/DVDs are underutilised, reflecting a shift away from traditional technologies. Surprisingly, the study reveals intriguing insights into the adoption of newer ICTs. While instant messaging applications like WhatsApp have gained global traction in education, with Nasution and Munandar (2023) highlighting their popularity, the results indicate a substantial 64.5% of teachers reporting never utilising WhatsApp. WhatsApp's versatility in facilitating communication, collaboration on group projects, and resource sharing (Stevani & Putro, 2020) positions it as an asset for educational engagement. WhatsApp, as a widely accessible and user-friendly communication tool, offers significant potential to support informal assessment practices in primary schools. It enables teachers to facilitate learner collaboration, share educational resources, and provide formative feedback beyond traditional classroom settings (Stevani & Putro, 2020). In resource-constrained environments, teachers can leverage WhatsApp for informal assessment activities such as peer discussions, assignment submissions, and prompt feedback, which complement and extend classroom-based assessment practices. Its commonness and ease of use position it as a practical tool for enhancing learner participation and enabling continuous evaluation, particularly in contexts with limited access to more advanced educational technologies. This unexpected underuse prompts a closer examination of the barriers or considerations influencing the reluctance to integrate such widely accessible tools into classroom assessment practices. Equally surprising is the reported underutilisation of webinars by 60.5% of teachers. Webinars, defined as live, internet-based events with applications in assessment activities (Gegenfurtner & Ebner, 2019), offer a flexible and cost-effective alternative to in-person conferences. The reluctance to embrace webinars might be attributed to the challenging context of frequent and permanent load shedding in South Africa significantly impacting reliable and stable internet access. Although the participating schools reported having internet access, the use of ICT-based assessment methods varied significantly due to infrastructure constraints. Assessment data indicated that while 48.5% of teachers used the internet for assessment purposes, only 3.5% reported using webinars, and 60.5% had never used them. This suggests that the available internet connectivity was insufficient to support data-intensive applications such as webinars, likely due to bandwidth limitations or unreliable connections. The diverse landscape of ICT integration in South African classrooms is further underscored by an open-ended question asking teachers if any ICTs were overlooked in the survey. While the majority stated that nothing was omitted, a few respondents highlighted the use of a 'visual laboratory', 'Telegram', and 'oral assessment'. The visual laboratory, a digital platform for creating visual depictions of experiments (Hernández-de-Menéndez et al., 2019), and Telegram, a secure instant messaging platform (Sevnarayan, 2023), contribute to the multifaceted nature of ICT integration in the South African educational context.

Regarding the 'how' (or 'what are they using it for') (RQ2), an open-ended question asked the respondents to indicate how they are making use of ICTs for assessment purposes. From the thematic analysis, six themes emerged which are considered next. It should be noted that

although the question asked to explain how ICTs were used for assessment purposes, other uses (unrelated to assessment specifically) were mentioned in some of the responses. We have included them in the thematic analysis, as this presented not only how ICTs are used for assessment purposes, but more holistically how ICTs were used in the classroom overall.

Theme 1: Formative and Summative Assessment

Under this theme, some of the participants indicated the following: 'Prepare learners for science and mathematics Olympiad' (Teacher 22), 'Allow learners to complete quizzes after experiments' (Teacher 24), 'For formative assessment' (Teacher 51), and 'Preparing assessment question papers and doing research on improving on question paper presentation' (Teacher 120).

The narratives of Teacher 22 and Teacher 24 link to the research of Ugwuanyi (2022) and del Calvo and Beck (2023), as they have mentioned the importance of formative assessment procedures in evaluating the learning outcomes of learners. Through formative assessment, teachers can quickly determine what changes to classroom instruction are necessary to enhance learners' learning and promptly modify their instructional approaches if needed, ultimately improving the learning experience for learners. Information and communication technology tools for formative assessment enable teachers to continuously collect feedback on learners' comprehension and advancement, which is important, for example, in Olympiad competitions (Teacher 22), as these types of competitions typically require thorough assessments of learners' abilities in these subjects, encompassing a range of assessment methods to evaluate their comprehension and problem-solving skills. The use of ICT tools, such as preparing assessment question papers and doing research on improving question paper presentation (indicated by Teacher 120), aligns with findings in the literature (Iqbal & Lawanto, 2022; Ross et al., 2020) in that it can enhance learning by providing supplementary resources and practice exercises. Within the TPACK framework, this demonstrates the integration of TK (e.g., use of digital tools for creating assessments) and PK (designing appropriate formative and summative assessment strategies), applied to CK in EFAL, mathematics, and natural sciences. Summative assessments are commonly employed to assess learners' knowledge and understanding at the conclusion of a learning period. Information and communication technology tools can streamline the administration and grading of assessments in this context. Teachers are responsible for both creating assessment question papers and integrating multimodal elements into them. Teachers are making efforts to enhance the format of these question papers to align them with the multimodal assessment framework. This act highlights the active role of teachers in implementing the framework rather than being passive recipients. Furthermore, the engagement of teachers in research to enhance the presentation of question papers demonstrates their dedication to continuously enhancing their practices in summative assessment. They utilise the framework's recommendations on creativity and multimodality to develop assessment materials that are more impactful and captivating.

Theme 2: Multimedia Learning

Under this theme, some participants' quotes are: 'Mostly use to play videos related to a certain topic presented' (Teacher 25) 'play audios and videos' (Teacher 38), 'showing learners YouTube videos' (Teacher 60), and 'I look for videos related to the topic and play it for

learners' (Teacher 84). These narratives align with the findings of the literature (AlTameemy et al., 2020; Ross et al., 2020), for example, with respect to Teacher 25's and Teacher 84's comments about e-assessment that have become widely used globally. Tests can include multimedia elements (AlTameemy et al., 2020), such as a video or a set of coloured images for the learners to analyse. The survey respondents showed a strong focus on utilising multimedia tools for assessment purposes. The theme of 'Multimedia Learning' involves the integration of diverse multimedia elements to enhance the learning and assessment experiences of teachers and learners. Some teachers (Teacher 25 and Teacher 84) mentioned the practice of incorporating videos relevant to specific subjects. This approach enables teachers to enhance their instructional materials by incorporating multimedia content, such as visuals and real-world examples, to improve learners' comprehension of the subject matter. Teacher 38 highlighted the utilisation of audio and videos in assessments. The multimodal approach accommodates diverse learning preferences and enhances learner engagement by utilising both auditory and visual stimuli. Furthermore, this multimodal approach has the potential to communicate intricate ideas effectively. Utilising YouTube videos as an educational tool for learners demonstrates the prevalence of educational content on platforms such as YouTube and acknowledges the valuable contribution that multimedia resources hosted on these platforms can make to the T&L experience. This integration illustrates how teachers combine TK (selecting appropriate multimedia tools) with PK (using multimodal instructional strategies) to make subject-specific content more accessible (CK), thereby supporting both teaching and assessment. These practices are consistent with the findings in the literature, specifically with the research conducted by AlTameemy et al. (2020), who found that tests can include multimedia elements. E-assessment, incorporating multimedia elements, has gained global popularity, according to the literature. Multimedia elements, such as videos and images, are incorporated into assessments to enhance the learning experience by offering a more comprehensive and interactive approach.

Theme 3: Personalised Learning

Teachers in the study demonstrated a nuanced understanding of personalised learning through their application of ICT tools. Teacher 23 explicitly emphasised, 'I use it to conceptualise a personalised learning environment' showcasing an awareness of tailoring education to individual needs. Teacher 26 referenced Bloom's Taxonomy, indicating a commitment to customising instructional approaches based on cognitive abilities and learning levels. Bloom's Taxonomy aids in establishing clear objectives, effective teaching strategies, and authentic assessments, promoting equitable education. Teacher 86's mention of seeking videos and gamified activities aligns with personalised learning, diversifying instructional materials to accommodate various modalities for a more inclusive learning experience. Teacher 114's proactive effort to 'search for relevant content related to the subject' suggests a personalised approach in curating subject-specific materials. Teacher 121 utilises technology to track learners' progress, highlighting a personalised learning connection by tailoring instructional strategies based on individual needs. Teacher 129's pursuit of alternative teaching methods for math aligns with personalised learning principles, acknowledging diverse learning styles. Teacher 137 leverages a smartboard to deliver lessons, customizing delivery for interactive and engaging sessions, catering to varied learning preferences. Teacher 189 utilizes a cell phone for solutions and alternative teaching methods, showcasing

a commitment to adapting instruction to individual learning needs. While the response rate was limited, the teachers emphasized crucial practices and challenges associated with technology in personalised learning. Their emphasis on using technology for real-time assessment data aligns with personalised instruction, allowing targeted interventions and customized learning experiences based on individual progress. This aligns with the TPACK framework, where TK (e.g., tracking learner progress digitally), PK (differentiated instructional strategies), and CK (understanding subject-specific challenges) intersect to enable personalised assessment practices. This insight reinforces the role of technology in facilitating a more adaptive and tailored educational environment, as recognised by the respondents.

Theme 4: Resource Discovery

Participants pointed out the value and use of ICT tools for resource discovery, indicating potential for improvement in optimising technology for this purpose. Teachers' narratives, such as 'Play videos and listen to recordings' (Teacher 21) and 'Review my lesson plan on the cell phone or laptop' (Teacher 45), suggest opportunities to enhance effectiveness and efficiency in resource utilization. This aligns with findings by Al-Maroof and Al-Emran (2018) and Cheah et al. (2023), emphasizing the importance of interactive features on Web 2.0 platforms for engaging learners through quizzes, games, simulations, and collaborative activities. Teachers 89 and 154's narratives correspond with literature (Kinyota, 2020; Ndibalema, 2021), calling attention to the substantial pedagogical shift required for transitioning from traditional to inquiry-based learning with technology. Challenges in adjusting assessment methods and finding relevant digital content aligned with the curriculum are acknowledged. From a TPACK perspective, these challenges highlight gaps in TK and PK, as teachers need targeted professional development to integrate ICT effectively with their CK for assessment purposes. The theme of 'Resource Discovery' through ICT tools emphasizes the transformative potential of technology in accessing and enhancing educational resources. While teachers are yet to fully exploit this potential for assessment purposes, their insights align with the impactful role of ICT in engaging learners and facilitating the creation and distribution of educational content. This theme resonates with the continuous influence of technology on contemporary education, as evidenced by research from Al-Maroof and Al-Emran (2018) and Cheah et al. (2023). Online learning platforms like Google Classroom, incorporating various tools within a unified framework, exemplify technology's role in shaping interactive and efficient learning experiences for assessment purposes. The ongoing influence of technology underscores its significance in modern education, emphasizing its crucial role in fostering dynamic and effective learning environments.

Theme 5: Educational Platforms

Participants express the following for this theme: 'I use master maths (Teacher 79). Kahoot is a game-based assessment tool. Students like it a lot for its fun way learning style. Students love Kahoot!' [It] is a game-based approach to learning and assessment. Teachers can choose to ready-to-go learning games or create their own in minutes. Host games live or as assignments.

Students can even create their own Kahoots to share with classmates, creating an interactive experience' (Teacher 108). 'The TED-Ed platform helps to create a lesson plan of customized questions and discussions. We can also use TED videos and TedEd lessons for creating [our]

own lessons on the topics interested. Users can then distribute these lessons, publicly or privately, and track their impact on the world, a class or an individual student' (Teacher 109). Can create fun and interactive presentations with Mentimeter. It is easy-to-use presentation software. It comes pre-loaded with education templates for the classroom. I use it like a listening skills assessment tool, icebreakers, formative assessments, post-lecture surveys, and polls (Teacher 111).

These narratives (Teachers 111 and 109) link to findings in the literature by Jadhav et al. (2022) and Haji (2022), as these authors pointed out the integration of Google Classroom, which is widely regarded as an effective platform for improving teachers' workflow in Cameroon. The focus was on examining the effects of Google Classroom on the instructional effectiveness of student teachers. Haji et al. (2017) employed an experimental methodology to implement the Google Classroom platform on 16 public, private and denominational secondary schools that were randomly selected. The findings indicated the presence of statistically significant disparities between the outcomes of the experimental and control groups in relation to the utilisation of Google Classroom.

The focus on educational platforms highlights their potential to enhance the quality of ICT use for assessment purposes significantly. Although only a few respondents mentioned these platforms, their insights are significant in the broader context of the numerous benefits of integrating technology into education. Platforms such as Kahoot!, TED-Ed, and Mentimeter are dynamic tools that enhance instruction, promote interactive learning, and monitor the progress of learners. These tools align well with the dynamic field of digital education, which is expected to have a significant impact on T&L by promoting engagement, customisation, and data-driven educational practices. The use of platforms such as Kahoot! and Mentimeter reflects effective TPACK integration, as teachers combine PK (pedagogical strategies such as gamified learning), TK (technical knowledge of these tools), and CK (designing subject-specific assessments) to enhance learner engagement and provide immediate feedback.

Theme 6: Printing and Document Handling

Participants reported using ICT for printing and document management. These tasks involve various aspects of printing and document handling, including printing documents, scanning materials, and digitally organising and managing different types of documents. They mentioned the following: 'Print out or photocopy worksheet and activities' (Teacher 46), 'Typing and Google' (Teacher 105), and 'I print out lesson plans and presentations slides' (Teacher 196).

Studies in the literature, such as those by Astalini et al. (2019) and Mombach et al. (2022), discuss the use of ICT for printing and document handling, as mentioned by Teachers 46 and 196. The researchers mentioned solving the disadvantages of conventional paper-based evaluation methods, such as assessment time and printing costs, by using assessment apps to evaluate exams regardless of the learners' name, colour, culture, or other characteristics. Hence, e-assessment may improve assessment objectivity. E-assessment, supported by assessment apps, can improve assessment objectivity by eliminating biases related to personal characteristics and enhance efficiency by reducing assessment time and printing expenses. The study by Mombach et al. (2022) discusses the use of ICT for printing and document handling, specifically mentioning eleven respondents. This finding can be connected to the

wider context of e-assessment and digital document management. Teachers who use ICT for printing and document handling can address challenges related to traditional paper-based evaluation methods, as noted by Astalini et al. (2019). The challenges encompass assessment time and printing expenses. The researchers highlighted the benefits of using assessment apps in conjunction with e-assessment, specifically emphasising the advantages of objectivity and efficiency. The utilisation of ICT for printing and document handling can enhance the efficiency of managing educational or professional documents. While less interactive than other tools, this still reflects TPACK elements, as teachers use TK (digital document tools) alongside PK (assessment preparation strategies) to manage subject-specific assessment materials (CK) more efficiently. Digital documents are more convenient to create, edit, store, and retrieve compared to physical documents.

LIMITATIONS

The study's exclusive focus on teachers from Gauteng Province introduces a potential sampling bias, limiting the generalisability of findings to broader regional or national contexts. The geographic focus on a single province further restricts the applicability of the results to schools in other provinces with potentially different socio-economic conditions, ICT infrastructure, and teaching environments. Additionally, self-reported data from surveys may be susceptible to response bias, influenced by participants' tendencies to provide socially desirable answers or inaccurately report ICT usage (Bergen & Labonté, 2020). The cross-sectional design employed in this study captures a singular snapshot of ICT usage, preventing the analysis of its evolution over time and restricting the establishment of causation (Wang & Cheng, 2020). A broader and more diverse sampling strategy, coupled with longitudinal research approaches, would offer a more comprehensive understanding of the multifaceted dynamics surrounding ICT adoption and usage among teachers.

CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

This study set out to address two key research questions: (RQ1) What ICTs do South African primary school teachers use for assessment purposes in EFAL, mathematics, and natural sciences? and (RQ2) How do teachers use ICTs for assessment in these subjects? Within the realm of the TPACK framework, qualitative insights illuminate the multifaceted ways teachers employ ICTs. PK is evident as teachers utilise ICTs for formative and summative assessments, fostering multimedia learning, tailoring education through personalised learning, facilitating resource discovery, engaging with educational platforms, and managing documents effectively. CK comes to the forefront as teachers apply ICTs to assess subject-specific content in areas like EFAL, mathematics, and natural sciences. TK is embedded in their choices of tools, encompassing personal computers, the internet, intranet, and mobile devices for assessment tasks. The results highlight disparities in access, particularly with certain ICTs marked as "not applicable" for assessment purposes. This underscores the need for a concerted effort by educational institutions and policymakers to enhance access and inclusivity. Initiatives should prioritise equipping teachers with specialised tools tailored for assessment tasks, encompassing assessment software, online testing platforms, and digital resources. Comprehensive evaluations of current accessibility and inclusivity conditions in ICT-based assessments are crucial for informed decision-making. To address these challenges and optimise the integration of ICTs within the TPACK framework, educational stakeholders should concurrently focus on enhancing PK by tailoring training programs to teachers' needs,

fostering a deep understanding of effective ICT integration in assessments. Similarly, efforts to bolster CK should be directed towards subject-specific applications of ICTs. Simultaneously, TK can be enriched by providing teachers with the skills to navigate and utilise various ICT tools effectively. In summary, embracing the TPACK framework necessitates not only recognising the diverse ways teachers employ ICTs but also acknowledging and addressing disparities in access. Through strategic initiatives and comprehensive evaluations, educational stakeholders can promote the effective integration of PK, CK, and TK, ensuring a more inclusive and proficient learning environment. This study contributes to the limited body of research on ICT-based assessment in South African primary schools by providing empirical insights into which ICT tools are used, how they are used, and the contextual factors shaping their integration. The findings emphasize the importance of aligning policies and professional development initiatives not only to ICT infrastructure needs, but also with the peer and institutional dynamics that shape teachers' adoption of ICT for T&L and assessment. Strengthening ICT-based assessment thus requires more than technological provision, it requires a nuanced understanding teachers' professional realities alongside targeted support to build their confidence, pedagogical capacity, and sustained engagement with digital tools to improve learner outcomes.

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[2] It should be noted that the abbreviation here was used by Campbell (2020) for South Australia (and not South Africa)

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