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Guiding principles for the integration of smartboards in Grade 12 classrooms at a Soshanguve secondary school

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Background: Guided by the Technological Pedagogical and Content Knowledge (TPACK) framework, this study employed a qualitative case study using semi-structured interviews and thematic analysis to examine smartboard integration in South African classrooms. Although smartboards have been widely deployed in under-resourced township schools to enhance teaching and learning, their effective use remains limited. Persistent barriers such as inadequate teacher preparation, unreliable infrastructure, and insufficient professional development continue to constrain meaningful implementation.

Aim: To investigate the integration and pedagogical use of smartboards in Grade 12 classrooms, focusing on challenges and emerging opportunities.

Setting: A secondary school in Soshanguve, a township in Gauteng province, South Africa.

Methods: An exploratory case study within an interpretivist paradigm was adopted. Qualitative data were collected through semi-structured interviews with teachers, supported by the TPACK framework.

Results: Teachers demonstrated foundational technological competence and recognised the pedagogical value of smartboards. However, unreliable infrastructure, limited training, and inadequate professional support restricted instructional innovation, preventing deeper integration into classroom practice.

Conclusion: While teachers showed willingness and positive attitudes towards smartboard use, systemic constraints continue to limit pedagogical transformation in township contexts.

Contribution: The study advances discourse on educational technology in resource-constrained environments by documenting contextual barriers and proposing targeted teacher development, strengthened infrastructure, and context-responsive implementation strategies.

Keywords: smartboards; technology integration; township schools; teacher competence; pedagogical strategies.

Introduction

The Global South has increasingly become the subject of scholarly focus across disciplines such as anthropology, education and political science (Haug, Braveboy-Wagner & Maihold 2021). Much of this discourse examines globalisation's influence and the integration of Western technologies into developing contexts (Cortes, Guix & Carbonell 2021). In South Africa, educational technology is framed as a transformative tool for addressing systemic socio-economic disparities, particularly in under-resourced communities (Achieng & Mlitwa 2024).

Within this context, the Gauteng Department of Education introduced smartboards in township schools, including those in Soshanguve, as part of a broader initiative to enhance learner engagement and improve academic outcomes (Kgosi, Makgato & Skosana 2023; Mugani 2020). Despite widespread installation, smartboards remain underutilised, with teachers often employing them as digital replacements for traditional chalkboards rather than as tools for interactive and learner-centred pedagogy (Mhlongo & Sedumedi 2023; Mihai 2020). This pattern points to a disjunction between policy-driven implementation and the realities of pedagogical integration.

This study investigates the practical realities and constraints associated with smartboard integration in Grade 12 classrooms at a secondary school in Soshanguve. Guided by the TPACK framework, the research explores two questions: (1) How do Grade 12 teachers at Soshanguve Secondary School apply their technological knowledge (TK) to integrate smartboards into teaching and learning? and (2) What pedagogical strategies accompany smartboard use in the classroom?

Although global scholarship on interactive whiteboards is expanding, there remains a marked dearth of empirical studies focusing on the pedagogical enactment of smartboards within South African township schools. This research gap is especially pronounced in relation to teachers' development across the TPACK domains, notably TK and Technological Pedagogical Knowledge (TPK). Recent findings by Gumede and Mavuru (2025) show that teachers in Gauteng frequently lack the pedagogical strategies necessary for effective smartboard use. Similarly, Shambare and Jita (2024) highlight systemic deficiencies in TPACK among science teachers in resource-constrained settings.

This study therefore contributes to an underexplored nexus of policy implementation, teacher professional development and classroom technology use. By situating smartboard integration within the TPACK framework, the research offers insights into both the enabling and constraining factors shaping educational technology practice in township school environments.

Literature review

Smartboards represent a significant advancement in educational technology, transforming static learning environments into interactive spaces (Akar 2020; Izadpanah 2024). Their multimedia capabilities cater to diverse learning styles, facilitating visual, auditory and kinaesthetic engagement (Aldalalah 2021). Several studies emphasise their role in enhancing learner participation and enabling teachers to deliver, annotate and adapt digital content dynamically (Khosa & Molotsi 2020).

However, effective integration is contingent not merely on access but on the pedagogical and content-related knowledge teachers bring to technology use. This study is therefore underpinned by the technological pedagogical and content knowledge (TPACK) framework, which offers a holistic view of teacher competence across technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK), as well as their intersections (TPK, technological content knowledge [TCK] and technological pedagogical content knowledge [TPACK]) (Koehler & Mishra 2009; Koehler, Mishra & Cain 2022). Recent research increasingly affirms the framework's value in contexts with unequal access to training and resources (Shambare & Jita 2024; Yusuf & Olumorin 2023).

Despite national ICT initiatives, many South African teachers still demonstrate limited proficiency beyond basic smartboard functions, such as text display or whiteboard annotation (Hussein et al. 2022). These limitations constrain the pedagogical affordances of smartboards, especially in enabling simulations, visual explanations and interactive problem-solving (Gumede & Mavuru 2025). This disjuncture reflects a broader concern: while hardware provision has improved, pedagogical fluency has not progressed in tandem.

The South African curriculum encourages learner-centred and inquiry-based learning (Bremner, Sakata & Cameron 2022). Smartboards inherently support such pedagogies through multimodal delivery and opportunities for learner participation. In theory, teachers can implement constructivist techniques, differentiated instruction, gamification and visual scaffolding (Mhlongo & Sedumedi 2023). Yet in practice, underpreparedness in TPK and TPACK limits these possibilities. As Gumede and Mavuru (2025) observed, smartboards in township schools are frequently used for content transmission, not interactive engagement, because of insufficient professional development. These patterns are echoed in broader Sub-Saharan African research, which stresses the critical role of context-responsive, TPACK-aligned training (Yusuf & Olumorin 2023).

Furthermore, infrastructural and socio-economic barriers ranging from intermittent electricity and poor connectivity to overcrowded classrooms exacerbate the gap between technological access and effective use (Mokgwathi et al. 2023). Teachers' autonomy is further curtailed by generic policy prescriptions that fail to address on-the-ground challenges (Moosa, Ncube & Ramnarain 2024). This fragmented policy-to-practice relationship reflects a critical tension in the literature: while digital tools are positioned as equalising forces, their integration in practice often reinforces existing inequalities.

Given this context, the current study applies the TPACK framework to examine how Grade 12 teachers in Soshanguve navigate these constraints in their smartboard usage. It draws attention to the interplay between structural conditions and teacher agency, highlighting the nuanced ways in which teachers attempt to enact technological integration amidst complex realities.

Methodology

Research design and approach

This study adopted a qualitative, exploratory case study design, situated within the interpretivist paradigm. The research was guided by the philosophy of interpretivism, which recognises the subjective and socially constructed nature of reality (Alharahsheh & Pius 2020; Nickerson 2022). Specifically, the study embraced social constructivism as its ontological position, viewing reality as constructed

through social interactions and individual experiences (Boyland 2019). This orientation allowed the researcher to explore deeply the perceptions and lived experiences of teachers integrating smartboards into their teaching practice at a Soshanguve secondary school.

Epistemologically, the study aligned with the interpretivist paradigm, acknowledging that knowledge is subjective and context-bound, constructed through engagement with participants' narratives (Bianchi 2023). The researcher's role was thus to interpret the participants' meanings and understand the context-specific experiences related to smartboard integration.

An inductive research approach was employed, enabling the researcher to move from specific observations to broader generalisations and theories (Vears & Gillam 2022). Given the limited research in this area, the inductive approach was appropriate to allow new themes and insights to emerge organically from the collected data (Abdukarimova & Zubaydova 2021).

The conceptual framework guiding the research design was the Research Onion model, proposed by Saunders, Lewis and Thornhill (2009). This framework provided a structured approach to methodological planning, encompassing layers such as research philosophy, strategy, approach and data collection procedures (Al-Ababneh 2020). In contrast, the TPACK framework functioned as the analytical lens, guiding the interpretation of findings by mapping teacher knowledge across technological, pedagogical and content domains (Koehler & Mishra 2009; Koehler et al. 2022).

Research strategy

The study employed an exploratory case study strategy to allow for in-depth examination of smartboard integration within a single school in Soshanguve (Gioia 2021; Tefo 2022). This approach was well suited for investigating complex, context-dependent phenomena and answering the 'how' and 'why' questions that framed the research (Mishra & Dey 2022; Wood, Sebar & Vecchio 2020).

Methodological choice

A mono-method qualitative design was used, prioritising depth of understanding over breadth (Kyngäs 2020). While mixed-methods approaches can be useful in educational technology research, a solely qualitative orientation was better aligned with the study's aim to capture lived experiences and contextual insights (Mik-Meyer 2020).

Time horizon

The study utilised a cross-sectional time horizon, with data collected at a single point in time (Cohen et al. 2002). This choice aligned with the study's exploratory nature and time constraints, as the research was to be completed within a limited timeframe of fewer than 12 months (Mugani 2020).

Population and sampling

The target population comprised teachers using smartboards in Grade 12 classrooms across township schools. The accessible population was narrowed to teachers at one secondary school in Soshanguve. Two non-probability sampling techniques were employed:

- Purposive sampling ensured that participants possessed direct experience with smartboard use, aligning with the study's objectives (Willie 2024).
- Convenience sampling was used to gain logistical access to the research site, leveraging the researcher's proximity (Pandey & Pandey 2021).

The final sample included five Grade 12 teachers. While appropriate for qualitative research, the reliance on convenience sampling may introduce bias, particularly in terms of representativeness. However, this limitation was mitigated by selecting participants with relevant, varied teaching contexts and ensuring rich, detailed narratives (Creswell & Poth 2016).

Data collection

Semi-structured interviews were used to elicit detailed responses while maintaining flexibility to explore emergent topics (Magaldi & Berler 2020). Interviews ranged from 45 min to 60 min in duration and were conducted in quiet spaces familiar to the participants. Interview protocols began with general questions and progressed to more specific probes concerning smartboard integration, technological support and pedagogy.

Data saturation was monitored throughout collection, and no new themes emerged after the fourth interview, supporting the adequacy of the sample size (Guest et al. 2020). Interviews were audio-recorded with consent, transcribed verbatim and anonymised.

Data analysis

Thematic analysis was applied using CAQDAS (NVivo) to facilitate systematic coding, storage and retrieval (Smit & Scherman 2021; Vignato et al. 2022). Codes were generated inductively, based on recurring patterns emerging from the transcripts, but later organised deductively according to the TPACK framework to guide thematic interpretation (Braun & Clarke 2019).

Themes were validated through peer debriefing and supervisor review, enhancing analytical rigour. While intercoder reliability was not formally assessed, coding was independently reviewed and refined collaboratively to enhance consistency.

Quality criteria and trustworthiness

To enhance the trustworthiness of the study, four criteria were rigorously applied: credibility, transferability, dependability and confirmability.

Credibility was ensured through prolonged engagement with participants, triangulation of data sources (interviews, field notes and literature) and member checking, where participants reviewed and verified transcripts and emerging interpretations to confirm accuracy and authenticity (Baixinho & Costa 2020; Shufutinsky 2020).

Transferability was addressed by deeply contextualising the study, offering thick descriptions of the school environment, classroom dynamics and participant demographics. These details enhance the applicability of findings to similar township schooling contexts (Weise et al. 2020).

Dependability was achieved through the creation of a structured audit trail documenting the research design, sampling procedures, coding processes and analytical decisions. This level of transparency ensures replicability and traceability for future research (Pandey & Pandey 2021).

Confirmability was maintained through ongoing researcher reflexivity and consultation with academic supervisors, which helped to identify and manage potential biases. All analysis procedures were logged using CAQDAS tools and retained in secure digital archives to preserve transparency and methodological integrity (Giustini 2024).

Ethical considerations

Ethical clearance to conduct this study was obtained from the University of South Africa College of Science, Engineering and Technology, School of Computing ERC on 03 February 2025. The ethical clearance number is 6750. Participants were informed of the study's aims and provided written, voluntary consent (Alderson & Morrow 2020). Confidentiality was upheld via pseudonyms and secure data storage. Participants retained the right to withdraw at any stage without consequence (Bos 2020).

The researcher's positionality as a postgraduate student with prior exposure to township education was acknowledged through reflexive practice, allowing for critical engagement with potential biases throughout the research process.

Results and findings

This section presents the results of the data analysis, organised around the research questions and themes that emerged during the coding process. The data from the interviews were analysed using qualitative coding and categorised according to the TPACK framework, which served as a lens to explore the integration of smartboards in teaching and learning. The findings are presented with an emphasis on the voices of the participants, as well as the challenges and opportunities identified through the analysis.

Table 1 presents a comparative overview of participant responses aligned with the core themes identified in the interviews. As shown in Table 1, while all participants acknowledged the presence of smartboards in their schools, only two reported consistent usage. This discrepancy highlights a significant gap between technological access and meaningful pedagogical integration, an issue central to the efficacy of smartboard use in township schools.

Findings for RQ1: *How do Grade 12 teachers at Soshanguve Secondary School apply their technological knowledge to integrate smartboards in their classrooms for teaching and learning?*

The application of TK by teachers was varied and largely dependent on the availability of functional technology.

Technological knowledge

Some teachers demonstrated a strong awareness of the potential of smartboards. They could identify the functions and features of the technology, such as the ability to display multimedia content, annotate lessons in realtime and use interactive features to engage learners. However, their ability to apply this knowledge was often compromised by inconsistent access to working smartboards:

> 'We know what the smartboard can do, but it's often not working, and there's no backup plan.' (Participant 1)

> 'The smartboard can be a great tool, but it's just not reliable enough for me to rely on it every day.' (Participant 2)

This illustrates a foundational understanding of TK but highlights a disconnection between knowledge and application because of infrastructural instability.

Impact on technological content knowledge

When smartboards were operational, teachers used them to enhance lesson delivery through content-specific visuals and simulations. One participant explained:

> 'When it works, I can show videos, animations and diagrams that make the lesson more engaging.' (Participant 4)

This demonstrates partial TCK, where technology supports content-specific instruction. However, the inconsistent utility of smartboards impeded sustainable integration.

Support and professional development

Participants highlighted limited support from the school's ICT committee:

> 'There's no structured training on how to effectively use smartboards in teaching. Sometimes we're left to figure it out on our own.' (Participant 3)

This highlights a gap in TPK, as teachers lack sufficient training to align digital tools with instructional strategies. These limitations are consistent with findings by Tondeur et al. (2016), who emphasise that without continuous and context-responsive professional development, the presence of digital infrastructure alone does not translate into effective pedagogical integration.

TABLE 1: Responses from all participants.

Question	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Teaching environment	Crowded classrooms, lack of resources.	Small classrooms with limited seating and ventilation issues.	Adequate space but lack of modern technology.	Overcrowded classrooms and outdated infrastructure.	Overcrowded classrooms, unclean and not conducive for learning.
Use of technology in school	ICT is available, but smartboards are rare.	Smartboards are present but not consistently used; basic technology like projectors is more common.	Limited technology use, smartboards available but not always functional.	Limited smartboard use because of technical issues; rely more on traditional methods.	Previously advanced with smartboards, but technology deteriorated. Smartboards are present but not always working.
Infrastructure support	Limited ICT tools for both teachers and learners.	School has Wi-Fi but no consistent access to tech for learners at home.	Learners from low-income families lack devices at home; school provides some tech support.	School infrastructure has Wi-Fi and smartboards, but home access is limited for most learners.	Some ICT infrastructure is present, but many learners come from disadvantaged backgrounds with limited home tech access.
Technological tools available	Projectors, smartboards, laptops, and Wi-Fi.	Smartboards, laptops and projectors, but availability fluctuates.	Smartboards and Wi-Fi, although usage is inconsistent.	Laptops, smartboards, projectors and Wi-Fi.	Smartboards, laptops, projectors and Wi-Fi present in some rooms.
Guidance on choosing tech tools	Minimal guidance, often teacher-driven experimentation.	ICT committee provides some support.	No official guidelines; decisions are based on trial and error or advice from other teachers.	ICT committee offers some guidance, but teachers mostly choose tools independently.	ICT committee available to guide on tech integration, but support is optional.
Teaching strategies used	Lecture, group discussions, peer teaching and scaffolding.	Group discussions, peer teaching and multimedia integration.	Lecture, discussions and multimedia integration when available.	Lecture, multimedia integration, peer teaching and scaffolding.	Question and answer, group discussions, scaffolding and peer teaching.
Pedagogical approach choice	Based on learner level and available resources.	Depends on learners' comprehension and tech availability.	Adaptive approach based on learner pace and content.	Pedagogical strategies vary depending on learner needs and technology availability.	Dependent on learner pace, socioeconomic context and availability of smartboards.
Technology to create engagement	Videos and smartboards when available.	Multimedia tools like videos and projectors.	Videos, images and interactive presentations.	Smartboards and interactive tools when possible.	Videos and smartboards stimulate learner engagement when tech works.
Impact of technology on learner learning	Improved attention and understanding through multimedia.	Smartboards and interactive tools increase engagement but limited because of availability.	Positive, although inconsistent, impact of smartboards on learning and engagement.	Increases learner focus when multimedia is available, but not a frequent occurrence.	Smartboards and multimedia increase engagement, with published research showing higher attention and results when used compared to traditional methods.
Integration of technology and learner needs	Technology helps to cater to different learning styles but is often inconsistent.	Technology accommodates various learners when available, but tech barriers exist for disadvantaged learners.	Technology helps with differentiation in instruction but is underutilised.	Accommodates different learners' needs when technology is functional.	Technology supports inclusive learning, especially through smartboards.
Technology supporting assessment	Mostly uses traditional methods for assessment; technology supports peer and group learning.	Technology is limited in supporting assessments because of inconsistent tech availability.	Some digital assessments, but heavily reliant on traditional tests and grading.	Minimal tech-supported assessments because of infrastructure challenges.	Little use of technology in assessments because of infrastructure issues and classroom dynamics.

ICT, information and communication technology.

Findings for RQ2: *What are the pedagogical strategies that teachers use in conjunction with smartboards in their classrooms for teaching and learning?*

Teachers reported adapting their pedagogical approaches in response to smartboard availability.

Pedagogical knowledge

Teachers demonstrated versatility in strategies ranging from lectures and discussions to peer teaching and scaffolding. Smartboards were used to project multimedia content that supported active learning:

> 'Using the smartboard helps my learners visualise complex concepts that would otherwise be difficult to understand with just a textbook.' (Participant 1)

This illustrates the application of PK, supported by TK, in the form of TPK, particularly where content presentation was enhanced by visual aids.

Active learning and collaboration

Several participants encouraged learner interaction with the smartboard:

> 'Sometimes I invite learners to come up and interact with the smartboard. It encourages them to engage more deeply with the material.' (Participant 5)

This demonstrates emergent TPACK, where technological tools are not only integrated with pedagogy and content but also reconfigure classroom dynamics.

Pedagogical adaptation

As one participant note:

> 'Sometimes the smartboard is just not available, so I adapt by using a traditional whiteboard or PowerPoint slides on a projector.' (Participant 2)

This reflects adaptive pedagogical responses constrained by unreliable technological infrastructure, limiting teachers' ability to enact TPK consistently.

Findings for other emerging themes

Infrastructural challenges

Overcrowding and inadequate infrastructure were common concerns:

> 'When there are too many learners in the class, it's hard for everyone to benefit from the smartboard, even if it's available.' (Participant 4)

These challenges not only inhibit access to technology but disrupt the alignment between pedagogy and content delivery, thereby hindering TPACK development.

Professional development gaps

Teachers repeatedly expressed the need for structured training:

> 'If we had more training on how to incorporate smartboards into our teaching, it would make a huge difference.' (Participant 3)

This points to a systemic failure to develop TPK and TCK, limiting the full integration of smartboards into content-aligned, pedagogically sound teaching. As observed in prior studies, sustained professional development is essential for fostering TPACK fluency (Gumede & Mavuru 2025; Yusuf & Olumorin 2023).

The findings reveal that while teachers possess foundational TK, they face considerable constraints in translating it into effective pedagogical practice. The integration of smartboards is inconsistently realised because of infrastructural challenges, limited professional development and a lack of context-specific support. Although elements of TPK, TCK and even full TPACK are present in isolated instances, systemic barriers prevent their sustained development. These results highlight the need for a holistic approach to educational technology integration, one that includes reliable infrastructure, targeted training and institutional support frameworks tailored to township school contexts.

Discussion

This study investigated the integration of smartboards in Grade 12 classrooms at a secondary school in Soshanguve, focusing on teachers' TK, pedagogical strategies and contextual challenges. Anchored in the TPACK framework, the findings reveal both the potential and limitations of smartboard use in under-resourced South African educational environments.

Teachers demonstrated foundational TK, recognising the affordances of smartboards for multimedia presentation, content annotation and visual enhancement. However, their limited access to functional devices, unreliable internet and inadequate maintenance impeded the translation of this knowledge into sustained classroom use. This reflects findings from Moosa et al. (2024), who identified infrastructural inconsistencies as a key barrier to meaningful technology integration.

As Table 1 illustrates, although smartboards were present in all classrooms, only two teachers reported consistent use. This access–usage gap highlights a disconnect between infrastructure availability and pedagogical application, highlighting the fragility of digital learning initiatives when systemic support is lacking. These infrastructural constraints disrupted not only the development of TK but also impeded the emergence of TPK and TCK, as teachers had few opportunities to align digital tools with their subject-specific pedagogies.

Importantly, these limitations have broader implications for teaching quality and equity. Learners in under-resourced schools face inconsistent exposure to digital learning experiences, deepening the divide between policy ambition and classroom reality. The underdevelopment of TCK means that smartboards are often used for content display rather than as tools to explore disciplinary concepts dynamically.

Despite these barriers, teachers consistently exhibited PK through strategies that prioritised learner engagement, particularly when smartboards were functional. They employed group discussions, interactive exercises and visual aids to support constructivist learning approaches. Yet, the inconsistent use of smartboards meant that opportunities to develop holistic TPACK competencies remained sporadic, especially in subjects requiring visual abstraction such as physical sciences.

A key insight from this study is the absence of structured professional development. Teachers predominantly relied on self-directed learning and informal peer networks to enhance their skills. This reliance on improvisation and fragmented support reflects a structural deficit in institutional investment in capacity-building. As noted by Major, Francis & Tsapali (2021), in low- and middle-income countries, technology-supported interventions are often implemented without sufficient professional development infrastructures, thereby limiting their pedagogical impact. Without consistent and well-supported training initiatives, the integration of technologies such as smartboards remains superficial, hindering the development of TPK.

Moreover, participants reported a lack of clear implementation guidelines, leaving them uncertain about best practices for technology integration. This ambiguity led to *ad hoc* decision-making rather than systematic instructional planning. The absence of policy frameworks tailored to the infrastructural and socio-pedagogical realities of township schools prevents smartboards from becoming transformative tools. Instead, they remain underutilised artefacts with latent potential.

Overcrowded classrooms, outdated facilities and intermittent internet access collectively undermine the development of Technological Pedagogical Content Knowledge (TPACK). When compounded by insufficient training and support, these conditions render even motivated teachers unable to fully realise the benefits of digital pedagogy. As such, the integration of smartboards must be reconceptualised not only as a technical challenge but also as a matter of systemic equity.

These findings highlight the urgent need for investment in stable infrastructure, ongoing professional development and context-specific pedagogical frameworks. Such interventions would help realise the full promise of smartboards, aligning them with the TPACK model to support meaningful, equitable and sustainable teaching practices.

These insights pave the way for targeted interventions aimed at enhancing smartboard integration through infrastructural

investment and capacity-building initiatives and form the basis for the concluding recommendations in the next section.

Conclusion

These findings offer implications for educational policy and technology integration initiatives, especially within the context of under-resourced South African schools. The study examined the integration of smartboards in Grade 12 classrooms at a secondary school in Soshanguve, focusing on teachers' technological knowledge, pedagogical practices and the contextual factors that shaped the use of smartboard technology. While participants demonstrated foundational technological knowledge and an appreciation for the pedagogical affordances of smartboards, the actualisation of these affordances was significantly constrained by unreliable infrastructure, inconsistent access to functioning equipment and limited institutional support.

By employing the TPACK framework, the study revealed how teachers navigated the intersections of technological, pedagogical and CK. When operational, smartboards enhanced learner engagement through multimedia content, interactive visualisations and collaborative classroom activities. However, these instances were often isolated and inconsistently applied because of infrastructural limitations such as overcrowded classrooms and poor technical maintenance. Additionally, a lack of structured professional development hindered the development of teachers' TPK and TCK, which are essential for effective integration.

In addressing these challenges, several implications for practice emerge. At the policy level, there is a clear need to establish a coherent framework for technology integration that includes enforceable infrastructure standards, equitable resource allocation and consistent technical support for township schools. Within schools, administrators should prioritise the routine maintenance of smartboards and ensure dedicated support for teachers facing technical difficulties. In parallel, teacher training programmes must be designed to move beyond basic operational knowledge, offering sustained and context-responsive professional development that explicitly incorporates the TPACK model. These programmes should be iterative, practically grounded and sensitive to the specific pedagogical contexts in which teachers operate. Curriculum planners should also embed smartboard integration examples into curriculum documents to encourage subject-specific application, particularly in content-heavy disciplines such as the sciences.

Future research should consider longitudinal approaches that assess how professional development impacts smartboard usage over time and how learners experience technology-enhanced teaching in resource-constrained contexts. Comparative studies between different socio-economic school environments may further clarify which conditions enable or inhibit sustainable technology integration.

Although smartboards present significant potential to improve teaching and learning in South African township schools, this potential can only be realised through coordinated efforts that strengthen infrastructure, invest in teacher capability and align policy with the lived realities of under-resourced classrooms. In doing so, smartboards can be transformed from underutilised technological artefacts into catalysts for pedagogical innovation and educational equity.

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CRediT authorship contribution

Thabo Mhlongo: Conceptualisation, Methodology, Data curation, Formal analysis, Investigation, Writing - original draft, and Project administration. Jeanne Kriek: Conceptualising; Validation; Supervision; Writing - review & editing. Patricia Gouws: Supervision, Methodology, Resources, Validation, and Writing - review & editing. All authors reviewed the article, contributed to the discussion of results, approved the final version for submission and publication, and take responsibility for the integrity of its findings

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclaimer

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References

Abdukarimova, N. & Zubaydova, N., 2021, *Deductive and inductive approaches to teaching grammar*, viewed n.d., from https://repo.journalnx.com/index.php/nx/article/view/2940.

Achieng, S.I. & Mlitwa, N.F., 2024, 'Promoting socio-economic inclusion in South Africa's higher education environment in the era of technology-enabled education', in *Proceedings of the 16th international conference on education and new learning technologies (EDULEARN24)*, pp. 1204–1211, IATED Academy. https://doi.org/10.21125/edulearn.2024.0412

Akar, H., 2020, 'The effect of smart board use on academic achievement: A meta-analytical and thematic study', *International Journal of Education in Mathematics, Science and Technology* 8(3), 261–273. https://doi.org/10.46328/ijemst.v8i3.908

Al-Ababneh, M., 2020, 'Linking ontology, epistemology and research methodology', *Science & Philosophy* 8(1), 75–91.

Aldalalah, O.M.A., 2021, 'The effectiveness of infographic via interactive smart board on enhancing creative thinking: A cognitive load perspective', *International Journal of Instruction* 14(1), 345–364. https://doi.org/10.29333/iji.2021.14120a

Alderson, P. & Morrow, V., 2020, *The ethics of research with children and young people: A practical handbook*, Sage, London.

Alharahsheh, H.H. & Pius, A., 2020, 'A review of key paradigms: Positivism VS interpretivism', *Global Academic Journal of Humanities and Social Sciences* 2(3), 39–43.

Allan, G., 2020, 'Qualitative research', in M. Lloyd-Evans (ed.), *Handbook for research students in the social sciences*, pp. 177–189, Routledge, London.

Baixinho, C.L. & Costa, A.P., 2020, 'Researchers' scientific credibility and knowledge transfer', *SciELO Brasil* 24, e20200008.

Bianchi, G., 2023, 'Epistemological and methodological challenges of subjectivity', in *Figurations of human subjectivity: A contribution to second-order psychology*, pp. 89–116, Springer, Cham.

Bos, J., 2020, *Research ethics for students in the social sciences*, Springer Nature, Cham.

Boyland, J.R., 2019, 'A social constructivist approach to the gathering of empirical data', *Australian Counselling Research Journal* 13(2), 30–34.

Braun, V. & Clarke, V., 2019, 'Reflecting on reflexive thematic analysis', *Qualitative Research in Sport, Exercise and Health* 11(4), 589–597. https://doi.org/10.1080/2159676X.2019.1628806

Bremner, N., Sakata, N. & Cameron, L., 2022, 'The outcomes of learner-centred pedagogy: A systematic review', *International Journal of Educational Development* 94, 102649. https://doi.org/10.1016/j.ijedudev.2022.102649

Cohen, L., Manion, L. & Morrison, K., 2002, *Research methods in education,* 6th edn., Routledge, London.

Cortés, J. D., Guix, M. & Bohle Carbonell, K., 2021, 'Innovation for sustainability in the Global South: Bibliometric findings from management & business and STEM fields in developing countries', *Heliyon* 7(8), e07809. https://doi.org/10.1016/j.heliyon.2021.e07809

Creswell, J.W. & Poth, C.N., 2016, *Qualitative inquiry & research design: Choosing among five approaches,* 4th edn., Sage Publications, Thousand Oaks, CA.

Gioia, D., 2021, 'A systematic methodology for doing qualitative research', *Journal of Applied Behavioral Science* 57(1), 20–29. https://doi.org/10.1177/0021886320982715

Giustini, D., 2024, *A practice-based epistemological perspective. Critical approaches to institutional translation and interpreting: Challenging epistemologies*, Routledge, London

Guest, G., Namey, E. & Mitchell, M., 2020, Collecting qualitative data: A field manual for applied research, Sage Publications, Thousand Oaks, CA.

Gumede, E.N. & Mavuru, L., 2025, 'Teachers' understandings and practices of using smartboards as digital tools to teach Grade 12 life sciences genetics', *International Journal of Learning, Teaching and Educational Research* 24(5), 323–338. https://doi.org/10.26803/ijlter.24.5.17

Haug, S., Braveboy-Wagner, J. & Maihold, G., 2021, 'The 'Global South' in the study of world politics: Examining a meta category', *Third World Quarterly* 42(9), 1923–1944. https://doi.org/10.1080/01436597.2021.1948831

Hussein, H.A., Ahmed, A.M.H., Shawkat, S.A. & Kamil, R.A., 2022, 'The effect of using smart board technology on the educational process in the colleges of education in terms of features and challenges', in *AIP conference proceedings*, vol 394, no 1, AIP Publishing, Melville, NY.

Izadpanah, S., 2024, 'Evaluating the impact of smart technology on academic eagerness, academic seriousness, and academic performance in elementary English language learners as a foreign language', *PLOS ONE* 19(5), e0300147. https://doi.org/10.1371/journal.pone.0300147

Kgosi, M.K., Makgato, M. & Skosana, N.M., 2023, 'Teachers' views on the application of educational technologies in the classroom: A case of selected Tshwane West secondary schools in Gauteng', *Journal of Curriculum Studies Research* 5(2), 151–166. https://doi.org/10.46303/jcsr.2023.23

Khosa, C. & Molotsi, A., 2020, 'Teachers' perspectives on the use of smart boards in teaching business studies in the Tshwane west district', in *Proceedings of the South Africa International Conference on Education 2020,* Johannesburg, South Africa.

Koehler, M. & Mishra, P., 2009, 'What is technological pedagogical content knowledge (TPACK)?' *Contemporary Issues in Technology and Teacher Education* 9(1), 60–70.

Koehler, M.J., Mishra, P. & Cain, W., 2022, 'TPACK in practice: How teachers use technology to transform learning', *Computers & Education* 182, 104504. https://doi.org/10.1016/j.compedu.2022.104504

Kyngäs, H., 2020, 'Qualitative Research and Content Analysis', in H. Kyngäs, K. Mikkonen & M. Kääriäinen (eds), *The application of content analysis in Nursing Science Research*, Springer, Cham.

Magaldi, D. & Berler, M., 2020, 'Semi-structured interviews', in V. Zeigler-Hill & T.K. Shackelford (eds.), *Encyclopedia of personality and individual differences*, pp. 4825–4830, Springer, Cham, Switzerland.

Major, L., Francis, G.A. & Tsapali, M., 2021, 'The effectiveness of technology-supported personalised learning in low-and middle-income countries: A meta-analysis', *British Journal of Educational Technology* 52(5), 1935–1964. https://doi.org/10.1111/bjet.13116

Mhlongo, T. & Sedumedi, T.D., 2023, 'Conceptual change in life sciences learning: The impact of teaching tools on knowledge representation', *Indonesian Journal of Science and Mathematics Education* 6(3), 300–310. https://doi.org/10.24042/ijsme.v6i3.18394

Mihai, M.A., 2020, 'The use of interactive whiteboards in urban Gauteng classrooms', *Perspectives in Education* 38(2), 318–336. https://doi.org/10.38140/pie.v38i2.4379

Mik-Meyer, N., 2020, 'Multimethod qualitative research', *Qualitative Research* 5, 357–374.

Mishra, S. & Dey, A.K., 2022, 'Understanding and identifying "themes" in qualitative case study research', *South Asian Journal of Business and Management Cases* 11(3), 187–192. https://doi.org/10.1177/22779779221134659

Mokgwathi, M.S., Graham, M.A. & de Villiers, J.J.R., 2023, 'School infrastructure challenges in South Africa: Experiences of high school principals and teachers', *South African Journal of Education*, 43(4), 1–13. https://doi.org/10.15700/saje.v43n4a2303

Moosa, S., Ncube, R. & Ramnarain, U., 2024, 'Translating policy to practice: The status of ICT in STEM education in South Africa', in *Information and communications technology in STEM education*, pp. 1–13, Routledge, London.

Mugani, P., 2020, *The pedagogical impact of smart classrooms on teaching and learning of grade 11 in the Tshwane South District*, University of South Africa Press, Pretoria.

Nickerson, C., 2022, 'Interpretivism paradigm & research philosophy', *Simply Sociology* 5(2), 50–67.

Pandey, P. & Pandey, M.M., 2021, *Research methodology tools and techniques*, Bridge Center, New Delhi, IN.

Saunders, M., Lewis, P. & Thornhill, A., 2009, *Research methods for business students*, 5th edn., Pearson Education, Harlow.

Shambare, B. & Jita, T., 2024, 'Understanding science teachers' TPACK for virtual lab adoption in rural schools in South Africa: A mixed-methods approach', *Frontiers in Education* 9, a1426451. https://doi.org/10.3389/feduc.2024.1426451

Shufutinsky, A., 2020, 'Employing use of self for transparency, rigour, trustworthiness, and credibility in qualitative organisational research methods', *Organisation Development Review* 52(1), 50–58.

Smit, B. & Scherman, V., 2021, 'Computer-assisted qualitative data analysis software for scoping reviews: A case of ATLAS.ti', *International Journal of Qualitative Methods* 20, 16094069211019140. https://doi.org/10.1177/16094069211019140

Tefo, R.M., 2022, 'The influence of smartboards on the teaching and learning of grade 12 physical science in Tshwane district', Unpublished thesis, University of South Africa, Pretoria, South Africa.

Tondeur, J., Van Braak, J., Siddiq, F. & Scherer, R., 2016, 'Time for a new approach to prepare future teachers for educational technology use: Its meaning and measurement', *Computers & Education* 94, 134–150. https://doi.org/10.1016/j.compedu.2015.11.009

Vears, D.F. & Gillam, L., 2022, 'Inductive content analysis: A guide for beginning qualitative researchers', *Focus on Health Professional Education* 23(1), 111–127. https://doi.org/10.11157/fohpe.v23i1.544

Vignato, J., Inman, M., Patsais, M. & Conley, V., 2022, 'Computer-assisted qualitative data analysis software, phenomenology, and Colaizzi's method', *Western Journal of Nursing Research* 44(12), 1117–1123. https://doi.org/10.1177/01939459211030335

Weise, A., Büchter, R., Pieper, D. & Mathes, T., 2020, 'Assessing context suitability (generalizability, external validity, applicability or transferability) of findings in evidence syntheses in healthcare – An integrative review of methodological guidance', *Research Synthesis Methods* 11(6), 760–779. https://doi.org/10.1002/jrsm.1453

Willie, M.M., 2024, 'Population and target population in research methodology', *Golden Ratio of Social Science and Education* 4(1), 75–79. https://doi.org/10.52970/grsse.v4i1.405

Wood, L.M., Sebar, B. & Vecchio, N., 2020, 'Application of rigour and credibility in qualitative document analysis: Lessons learnt from a case study', *Qualitative Report* 25(2), 456–470. https://doi.org/10.46743/2160-3715/2020.4240

Yusuf, M.O. & Olumorin, C.O., 2023, 'Teachers' TPACK competency for ICT integration in teaching and learning in African secondary schools', *Education and Information Technologies* 28(2), 1257–1274.