ARTICLE

Exploring the integration of Artificial Intelligence into Geography education through a hybridised TPACK–Place–AI framework

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ABSTRACT

Since the 1960s, Geography educators have used digital technologies such as GIS and remote sensing to enrich spatial learning. The rise of artificial intelligence (AI) extends these tools by enabling transformative, data-driven, and personalised learning experiences while fostering essential 21ª Century skills. However, many educators remain unaware of AI's potential benefits and risks. Situated within South Africa's unequal digital landscape, this study aims to raise awareness and broaden Geography educators' understanding of effective and ethical AI integration in Geography education. It proposes a hybrid TPACK-Place-AI framework that extends the established Technological, Pedagogical and Content Knowledge model through insights from a critical pedagogy of place. The framework emphasises that AI integration must be pedagogically sound and socially responsive, foregrounding ethics, justice, power, and context. The paper thus offers a theoretical foundation for critically engaging with AI in Geography education.

Keywords: Artificial Intelligence, Geography education, Pedagogy, Place, Technology

INTRODUCTION

Geography education plays a crucial role in developing learners' understanding of the complex interconnections between humans and the environment. Teaching with technology often poses challenges for educators, particularly as new tools demand evolving competencies. As Artificial Intelligence (AI) advances, opportunities then emerge to integrate these innovations into Geography education (Chang & Kidman, 2023). Many educators, however, lack the knowledge or confidence to use AI effectively, with concerns around trust, ethics, and job displacement contributing to reluctance (Janowicz et al., 2020). In developing world contexts such as in South Africa, integrating AI is further complicated by persistent digital divides, unequal access to connectivity, and limited teacher training. This paper offers a conceptual response to the limited awareness and preparedness of South African Geography educators to engage with AI responsibly and ethically. By situating this challenge within debates on equity, pedagogy, and technological transformation, it foregrounds the need for frameworks that support critical and contextsensitive adoption of AI in Geography classrooms.

The paper proposes the Technological, Pedagogical and Content Knowledge (TPACK) model as a foundational framework for effective AI integration. Drawing on a critical pedagogy of place, this approach ensures AI use remains contextually grounded, ethically responsive, and attentive to justice and locality. Within the current AI landscape, TPACK aligns technological affordances with disciplinary and pedagogical knowledge, promoting integration that is both meaningful and educationally sound. Alongside a critical pedagogy of place, this study extends to include ethical and power-related dimensions signalling the need for a more holistic framework. This hybrid TPACK-Place-AI perspective forms the theoretical basis for this conceptual paper and will inform future empirical work engaging geography educators in the practical application of AI tools.

THE DIGITAL DIVIDE IN SOUTH AFRICA

The digital divide in South Africa continues to be a critical concern that is marked by inequitable access to information and communication technologies among diverse demographic groups. Philip & Williams (2019) define the digital divide on a global scale as the disparity in economic resources between individuals and regions with varying socioeconomic conditions that impacts their ability to access information and communication technologies. Although significant progress has been made in mobile network infrastructure, with the Independent Communications Authority of South Africa (ICASA) reporting comprehensive coverage (100% for 2G, 99% for 3G, and 98.5% for LTE/4G), substantial disparities remain (Colmer, 2025).

The high cost of internet services, which limits accessibility for economically disadvantaged communities, can be regarded as the main driver for these disparities. Colmer (2025) asserts that the digital divide is often not defined by the availability of 96 Journal of Geography Education in Africa infrastructure but rather by the affordability of services, which intensifies the marginalisation of low-income communities in the digital network. The consequences of this digital divide in South Africa are significant, particularly in the fields of education and employment. For example, an estimated 750 000 learners discontinued schooling during the COVID-19 pandemic because of insufficient access to remote learning technologies (Mlaba, 2021). Likewise, around 2.2 million people lost their jobs and experienced limited internet access that hindered their opportunities to pursue new employment. This highlights the urgent need for cost-effective internet services to facilitate equitable access to educational and labour market resources (UNDP South Africa, 2024).

How the digital divide affects educational institutions

The digital divide continues to exacerbate educational inequality in South Africa by restricting access to digital learning tools and widening the skills gap among learners from different socioeconomic backgrounds. Many schools, particularly in rural and disadvantaged urban areas, face unreliable internet connectivity, insufficient digital devices, and limited teacher training in information and communication technology. Only 22% of South African schools have fully functional computer labs, forcing most learners to rely on costly mobile data to access online materials (UNESCO, 2023). This highlights the stark divide between well-resourced institutions that effectively employ digital technologies and under-resourced schools where educators and learners encounter persistent barriers to digital engagement.

During the COVID-19 pandemic, the digital divide disproportionately affected learners from underprivileged backgrounds, limiting their capacity to participate in online learning activities. When lockdown began in March 2020, laptops accounted for only 28.1% of South Africa's device market, while tablets made up 2.02% and mobile phones dominated at 69.17%, compared to Germany's 52.29% market share for desktops (Hlatshwayo, 2022).

This highlights the limited accessibility of laptops essential for online learning. Although universities offered data subsidies and loaned devices, many students particularly those far from campus continued to struggle with unreliable connectivity and hybrid learning formats. Maniram (2023) notes that learners from under-resourced schools also lack digital literacy, compounding inequities in technology-driven education. Here, digital literacy extends beyond technical proficiency to include the ability to critically evaluate and ethically apply digital tools, such as interpreting spatial data, recognising algorithmic bias, and analysing digital representations of place.

Government initiatives such as SA Connect aim to reduce the digital divide by improving internet access in schools and supporting university-driven digital infrastructure programmes. For instance, the University of Cape Town and University of the Witwatersrand offer zero-rated access to learning platforms, allowing students to use educational resources without data costs. However, lasting progress requires sustained investment in affordable broadband, educator training, and curriculum reform that embeds digital literacy at all levels (Scott, 2023). Without these measures, the digital divide will continue to hinder South Africa's pursuit of an equitable and globally competitive education system.

THE BENEFITS AND CHALLENGES OF INTEGRATING AI INTO EDUCATION

The notion of AI is not new and has been around for many decades. Since its introduction in 1956, the definition of AI has evolved to reflect the substantial progress made in its capabilities. Popenici & Kerr (2017, p.2) define AI as 'computing systems that are able to engage in human-like processes such as learning, adapting, synthesising, self-correction and the use of data for complex processing tasks'. Generative AI (GAI) involves machine learning from patterns in data and then using these patterns to generate new content, such as images, text, or multimedia experiences. One of the most compelling promises of GAI in education lies in its potential to democratise access to quality learning resources (Pramjeeth & Ramgovind, 2024). Through AI-driven content generation, educational materials can be produced at scale and localised to cater to diverse languages, cultures, and educational contexts. This capability enables personalised learning, where AI dynamically generates content suited to each learner's preferences, abilities, and pace (Rakuasa, 2023). Learners with specific educational needs benefit from tools such as speech-to-text and text-to-speech technologies for visual impairments and adaptive 3D models for learning difficulties. Similarly, struggling learners receive customised feedback and targeted interventions, while more advanced learners can access enriched materials, independent study options, and personalised activities that extend intellectual growth (Pramjeeth & Ramgovind, 2024).

Despite its potential, GAI in education presents significant challenges. Ethical concerns regarding bias, authenticity, plagiarism, and content ownership demand critical attention, while issues of data privacy and security require robust safeguards to protect leaners' personal information. Huang et al. (2021) identify inadequate infrastructure and unequal access to technology as key barriers to AI integration in education, including the use of GAI. In South Africa, Colmer (2025) notes that these challenges are intensified by the high cost of digital services. Many schools and regions lack essential resources such as smart devices, reliable internet, and AI-based software. Over half of South African schools remain without internet access for e-learning, excluding millions of learners from the digital economy and the development of vital digital literacy skills (Malinga, 2022). According to the National Education Infrastructure Management System report from 2021, of the 23 258 primary and high schools (including 2154 independent schools) reported by the South African government in 2022, only 4695 (20%) had internet access available for teaching and learning (DBE, 2021). Additionally, 6770 schools (29%) had internet access restricted solely to administrative use, with no provision for teaching and learning (DBE, 2021). Implementation of the SA Connect broadband project is slow, raising critical questions for education. Despite this, educators must still be made aware of the opportunities, value, and risks associated with technology and AI in teaching and learning.

THE TPACK FRAMEWORK: STRENGTHS AND LIMITATIONS

While the TPACK framework provides a valuable foundation for understanding the integration of technology, pedagogy, and content knowledge, it remains largely silent on the ethical, contextual, and sociopolitical dimensions of educational technology. This is significant when considering AI, which is not merely a neutral tool but a sociotechnical system shaped by human values, algorithms, and data infrastructures that have embedded biases (Williamson et al., 2020). For this reason, insights from critical pedagogy of place can enrich this TPACK framework.

The intersection of pedagogical content knowledge, technological content knowledge, and technological pedagogical knowledge can produce hybrid forms of knowledge of relevance to understanding the applications of AI in education (Koehler & Mishra, 2009; Shambare & Simuja, 2024). A strength of TPACK is that it can consider the interrelatedness of these different content domains. Effective teaching with technology requires not only fluency in each knowledge domain but also cognitive flexibility to adapt them to particular teaching contexts (McCrory, 2014). However, this integration is not always linear or cumulative (Niess, 2019; Engin et al., 2022). Educators may have stronger competencies in some domains at certain times, and the development of TPACK is iterative and context dependent. Whilst this model offers a valuable lens for understanding technology integration, TPACK's treatment of context remains underdeveloped (Valtonen et al., 2022).

A critical pedagogy of place

A critical pedagogy of place situates teaching and learning within the social, cultural, ecological, and political contexts of specific localities. It challenges placeless curricula by emphasising how knowledge is shaped through relationships with land, histories, and communities (Gruenewald, 2003; Greenwood, 2013; Ontong, 2022). Integrating ecological literacy with social justice, it encourages learners to critically examine how local environments are affected by structural, economic, and technological forces (McInerney et al., 2011; Greenwood, 2013). In Geography education, this pedagogy links disciplinary content to lived realities using, for instance, local water shortages, informal settlement growth, or land-use conflicts to explore sustainability, inequality, and climate change (Sobel, 2004; Le Grange & Ontong, 2018). Education thus becomes not only learning in place but learning for place by cultivating civic responsibility, ecological care, and transformative action (Gruenewald, 2003; Ontong, 2019).

A critical pedagogy of place extends TPACK beyond its epistemological boundaries by situating knowledge within justice, power, and sustainability. In Geography education, this lens can reveal how AI technologies intersect with spatial realities, such as predictive GIS models that privilege data-rich urban areas while rendering informal settlements invisible (Mhlanga & Moloi, 2020), or GAI tools that reproduce Eurocentric representations of landscapes while marginalising indigenous knowledge (Perera et al., 2025). Embedding TPACK within a critical pedagogy of place enables educators to align technological and disciplinary knowledge while interrogating how AI shapes learners' relationships with their environments. These perspectives ensure that AI is not adopted as a 'neutral' tool but rather is critically examined for its potential to reinforce or disrupt spatial and epistemic inequalities. In so doing, spatial awareness becomes an ethical practice that helps learners question how space reflects power, inequality, and vulnerability (Gruenewald, 2003; Castree, 2017) and use AI-supported mapping to connect technological practice with moral and civic reasoning (Morgan, 2012).

Towards a hybrid framework: TPACK-Place-AI

While TPACK is not an exhaustive lens, it provides a foundational anchor for examining how technology, pedagogy, and content interact in educational practice. Its strength lies in emphasising the dynamic interplay of these domains and the need for educators to navigate their intersections rather than treat them in isolation. Extending this framework through a critical pedagogy of place deepens the analysis, ensuring that AI integration is not only pedagogically effective but also responsive to questions of ethics, justice, power, and context.

A hybrid TPACK-Place-AI framework is proposed as a holistic theoretical construct for educators. The framework emphasises that effective AI integration in Geography education depends on educators' capacity to navigate the cognitive and ethical dimensions of teaching with technology. For example, using AI-powered climate simulations in the CAPS strand 'Place and Environment' (DBE, 2011) can enhance enquiry-based learning about local drought patterns. This place-based lens requires learners to question whose data informs such models, how predictive outcomes shape policy, and what implications arise for vulnerable communities. In this way, a critical pedagogy of place ensures AI fosters critical and socially responsive geographical understanding rather than merely optimising learning outcomes.

Through a TPACK lens, AI integration can align technological tools with Geography's disciplinary purposes (content knowledge) and employ pedagogies that promote enquiry, ethical awareness, and justice. As McCrory (2014) cautions, technology should not simply replicate traditional practices but enable new forms of learning that would otherwise be difficult or impossible. Similarly, Onyema (2019) argues that educators must embrace innovation as education evolves. In Geography, GAI can model processes, simulate perspectives, and enhance creativity. However, viewed through a critical pedagogy of place, such tools require reflection on how AI may reproduce bias, distort local realities, or privilege dominant knowledge systems (Gruenewald, 2003; Williamson et al., 2020). The task, therefore, is not only to adopt AI within TPACK but to ensure its use remains ethically grounded, contextually responsive, and attuned to spatial justice.

Figure 1 presents a hybrid model that integrates the TPACK framework (Koehler & Mishra, 2009) with the principles of a critical pedagogy of place (Gruenewald, 2003; Greenwood, 2013). The three intersecting domains; content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK) form the TPACK core and is extended into the TPACK-Place-AI nexus. Surrounding this core are four guiding dimensions drawn from critical pedagogy of place: ethics, justice, power, and context. Together, these layers emphasise that integrating AI in Geography education must be both technologically robust and socially responsive, critically engaging with local realities, power relations, and ethical concerns.

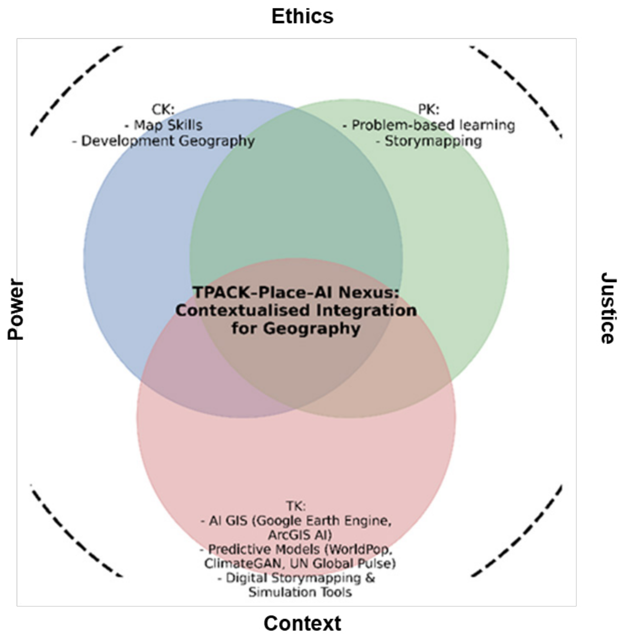

Figure 1. A hybridised TPACK-Place-AI nexus framework.

EXPLORING PRACTICAL AI INTEGRATION IN GEOGRAPHY EDUCATION

In an increasingly globalised world, Geography provides critical insights into how humanenvironment interactions shape issues such as climate change, urbanisation, migration, and trade, and the study of people, cultures, and spatial processes (Radcliffe, 2017). Technological tools such as GIS enable spatial analysis and data visualisation, enhancing the mapping of environmental change and regional connectivity (Manakane et al., 2023; Carow & Pretorius, 2024; Patel & Ragolane, 2024). Integrating AI with geographic knowledge enhances this capacity by supporting data analysis and pattern recognition for informed decision-making (Huang et al., 2021).

Technological Knowledge (TK), Place and AI

Technological knowledge within the TPACK-Place-AI framework refers to educators' capacity to select, apply, and critically engage with AI tools that enhance geographical inquiry and understanding. AI-driven applications such as machine learning for spatial analysis, intelligent GIS systems, and AI-powered virtual fieldwork platforms (Zhou, 2023) can assist in processing complex geospatial data and visualising environmental patterns in locally meaningful ways. These tools can automate data analysis, provide adaptive feedback, and personalise instruction according to learners' needs. However, within a critical pedagogy of place, educators must be proficient in the technical operation of these tools and also interrogate their ethical and contextual implications by questioning whose data is represented, which voices are amplified or silenced, and how AI reshapes learners' relationships with place. In this sense, educators and learners alike must remain critical, reflective, and discerning users of AI technologies.

Pedagogical Knowledge (PK), Place and AI

Within the TPACK-Place-AI framework, pedagogical knowledge involves understanding how teaching strategies can be enhanced through the thoughtful and ethical use of artificial intelligence. AI-powered systems can support differentiated and adaptive learning by analysing learners' engagement patterns, providing targeted feedback, and scaffolding inquiry-based tasks (Patel & Ragolane, 2024). When applied critically, such tools can enable Geography educators to personalise learning experiences while maintaining a focus on higher-order thinking and critical spatial inquiry. However, from a critical pedagogy of place perspective, AI must complement and not replace pedagogies that cultivate reflection, collaboration, and contextual understanding. Educators should therefore align each pedagogical choice with appropriate content, technologies, and AI applications, ensuring that learning remains inquiry-driven, place-conscious, and responsive to issues within local environments. For example, Geography educators might use ArcGIS AI to model drought frequency across provinces, followed by learner-led discussions on the human and ecological consequences of water scarcity.

Content Knowledge (CK), Place and AI

Content knowledge within the TPACK-Place-AI framework refers to the disciplinary understanding that enables educators to interpret and teach core geographical concepts and processes through AI-enhanced methods. AI-driven tools such as climate modelling platforms, automated geospatial analysis systems, and immersive virtual simulations (DeMers, 2016; Lee et al., 2025) allow learners to explore dynamic representations of realworld processes like land-use change, climate variability, and spatial inequality. However, effective use of these technologies requires educators to accurately interpret AI-generated outputs, evaluate their validity, and connect them to broader geographical theories and contexts. Without this foundation, educators risk misrepresenting data or overlooking biases within AI models. From a critical pedagogy of place perspective, content knowledge also involves situating AI applications within local and global realities.

Pedagogically useful AI tools for Geography education

The integration of AI tools within Geography education offers significant potential to enhance teaching and learning by connecting technological innovation with disciplinary depth and contextual relevance. AI applications can process vast geographical datasets, detect spatial patterns, and visualise complex environmental changes to support inquirydriven learning (Lavallin & Downs, 2021). Within the Technological Knowledge (TK) domain, tools such as ArcGIS AI and Google Earth VR provide immersive, place-based learning experiences that can enable learners to explore real-world terrains, analyse spatial data, and visualise phenomena in three dimensions. Similarly, Tinkercad allows learners to model geographical processes like erosion or plate tectonics, fostering active engagement through simulation and design. AI also intersects with Pedagogical Knowledge (PK) through adaptive and interactive tools that personalise learning and promote critical inquiry. Platforms such as CENTURY Tech can identify learners' strengths and gaps to create individualised pathways, while Gradescope supports automated yet flexible assessment and feedback. In the Content Knowledge (CK) dimension, applications like IBM's Environmental Intelligence Suite and AI-powered GIS platforms enhance conceptual understanding by linking theory to real-time global and local data (Li & Hsu, 2022).

From a critical pedagogy of place perspective, these technologies must be applied with ethical awareness and contextual sensitivity. Educators should interrogate how AI narratives could reinforce or challenge existing power structures (Wilby & Esson, 2024). Chatbots such as ChatGPT or Copilot can facilitate explanation and reflection but must be critically mediated by educators who possess strong disciplinary knowledge to validate AI-generated content and prevent misinformation.

Effective AI integration within Geography education therefore requires that technological possibilities are pedagogically purposeful, content-rich, and place-responsive across TPACK's core domains. Table 1 summarises some of the most commonly available AI tools, their primary functions, relevant TPACK domains, pedagogical applications, and associated ethical considerations.

Table 1. Properties of the major AI tools discussed in this study.

Tool name	Primary function of the AI tool	TPACK domain(s) (Fig. 1)	Example of its use in Geography education	Key ethical considerations
ArcGIS AI	Spatial data analysis and predictive GIS modelling	Technological + Content + Pedagogical Knowledge	Used to visualise drought patterns, flood risks, or urban expansion to support inquiry-based learning	Bias in datasets representing informal or marginalised communities; ethical data sourcing
CENTURY Tech	Adaptive learning and analytics platform	Technological + Pedagogical Knowledge	Personalises Geography learning by tracking progress and providing adaptive feedback	Learner data privacy; transparency of algorithms
ChatGPT / Copilot	AI text-generation and tutoring systems	Technological + Pedagogical + Content Knowledge	Facilitates explanation, reflection, or the generation of inquiry prompts in Geography lessons	Risk of misinformation; ensuring teacher-mediated use and source validation
Google Earth VR	Immersive 3D exploration of real-world terrains	Technological + Pedagogical Knowledge	Allows virtual fieldwork and spatial exploration when physical access is limited	Accessibility barriers in low-bandwidth contexts; representation bias
Gradescope	AI-assisted assessment and feedback tool	Technological + Pedagogical Knowledge	Supports automated marking of map-work and essays, reducing feedback turnaround time	Risk of over-reliance on automation; ensuring fairness in assessment
IBM Environmental Intelligence Suite	Environmental and climate data analytics	Technological + Content Knowledge	Analyses real-time climate or pollution data for learners to interpret spatial patterns	Ethical use of proprietary data; maintaining contextual relevance
Tinkercad	3D design and simulation platform	Technological + Content Knowledge	Used to model geomorphological processes such as erosion or land formation	Oversimplification of complex systems; access to devices

RISKS ASSOCIATED WITH AI INTEGRATION IN GEOGRAPHY EDUCATION

Within the TPACK-Place-AI framework, risks emerge when technological knowledge is privileged over pedagogical intent, disciplinary grounding, or contextual sensitivity. While AI can enrich Geography education through augmented reality, predictive modelling, and adaptive feedback systems, these technologies can introduce pedagogical, ethical, and sociotechnical challenges. Over-reliance on AI may diminish learners' capacity for critical inquiry and independent thought, while unmonitored systems risk reproducing inaccuracies and bias. The persistent digital divide further amplifies inequities in access and opportunity (Huang, 2023; Patel & Ragolane, 2024). Ethical and place-conscious practice is therefore essential to ensure that AI integration enhances rather than undermines educational integrity.

Data privacy and security

AI technologies often depend on the collection and analysis of learners' data, raising concerns about privacy and surveillance. Geography educators must ensure compliance with national data protection regulations such as South Africa's Protection of Personal Information Act (No. 4 of 2013). Responsible integration demands transparency regarding how data are collected, used, and stored, along with explicit informed consent from learners.

Ethical concerns

Location-based AI tools and geospatial platforms can expose learners to unauthorised data tracking and potential misuse (Huang, 2023). Furthermore, algorithms trained on biased datasets may produce inequitable or exclusionary outputs. A critical pedagogy of place urges educators to question whose perspectives are embedded within these technologies and how they shape spatial understanding. Ethical AI use requires active scrutiny, open disclosure, and dialogue about the implications of technological choices within local contexts.

Dependence on technology

Uncritical dependence on AI risks marginalising the relational and reflective dimensions of teaching. Technology should complement not replace the human educator (Holmes et al., 2019). Within the hybrid framework, educators must maintain oversight across the technological, pedagogical, and content domains whilst aware of constraints such as South Africa's uneven digital infrastructure. Technology should therefore function as a scaffold for engagement, not as a substitute for human agency or interaction.

Data bias and misinformation

AI-driven spatial tools can perpetuate bias when underlying datasets exclude or distort marginalised communities (Bolstad, 2022). Without sufficient disciplinary expertise, both educators and learners risk misinterpreting AI-generated insights, reinforcing existing geographic inequities (Huang, 2023). The content knowledge dimension of the TPACKPlace- AI framework emphasises educators' responsibility to validate and contextualise such outputs, linking them to the socioenvironmental realities of local spaces.

Loss of critical and spatial thinking

Automation of analytical tasks can erode learners' critical and spatial reasoning skills if it replaces rather than supports inquiry-based learning (Lee et al., 2025). Geography's pedagogical strength lies in its focus on observation, analysis, and reflection – skills that must remain central even in AI-mediated classrooms. Assessment design should therefore foreground critical thinking and problem-solving, ensuring learners to interrogate, rather than merely reproduce, AI-generated content

CONCLUSIONS AND RECOMMENDATIONS

The meaningful integration of AI into Geography education requires educators to possess a robust combination of disciplinary, technological, and pedagogical knowledge. However, many educators might still lack sufficient exposure to AI-based educational tools, limiting effective adoption and confidence in their use. Concerns persist that AI may displace educators or introduce ethical and data-related risks (Janowicz et al., 2020). A central challenge lies in equipping Geography educators with the necessary training to implement AI tools appropriately and purposefully in their classrooms (Li & Hsu, 2022). To enable effective use of AI, educators must receive sustained professional development, ongoing institutional support, and the confidence to engage critically with these technologies (Chang & Kidman, 2023). Within the TPACK-Place-AI framework, maintaining pedagogical and technological balance is essential to ensure that AI functions as an ally rather than a substitute for human teaching and learning. Strengthening spatial awareness through AIsupported learning sustains Geography's disciplinary identity. By combining technological competence with critical spatial thinking, the TPACK-Place-AI model prepares educators to cultivate geographically literate, ethically grounded learners. When aligned with inquirybased and problem-solving pedagogies, AI tools can support learners in developing both analytical and conceptual understanding (Bolstad, 2022). Adaptive feedback systems (Huang, 2023) can further personalise learning, but technological efficiency should not eclipse the human dimensions of dialogue, reflection, and ethical awareness.

In the South African context, progress in AI integration could be constrained by the digital divide. Inequitable access to infrastructure and digital resources risks widening existing educational disparities, particularly in under-resourced schools. Addressing this requires investment not only in infrastructure but also in teacher training and policy reform to ensure AI functions as a means of inclusion rather than exclusion. In such contexts, educators retain a central role as interpreters and mediators of AI-generated content. The following recommendations are proposed for educators and policymakers:

- *Institutionalise TPACK-Place-AI professional learning.* Teacher education programmes and in-service training should explicitly embed the TPACK-Place- AI framework to help educators understand the interplay between content, pedagogy, and technology within ethical and contextual boundaries.
- *Advance critical AI literacy and reflective practice*. Educators and learners must develop the capacity to interrogate AI-generated data, identify algorithmic bias, and evaluate the accuracy and implications of outputs.
- *Prioritise equity through infrastructure and policy reform.* Government must invest in reliable infrastructure and equitable access to digital technologies, particularly in rural and under-resourced schools. Policymakers should establish national guidelines for AI use in education that address ethical standards, openaccess resources, and low-bandwidth adaptations ensuring AI reduces rather than reinforces the digital divide.
- *Embed ethical and legal safeguards.* AI applications should adhere to national data protection laws such as South Africa's Protection of Personal Information Act. Institutions must develop clear policies outlining how data from learners are collected, stored, and analysed.
- *Foster place-based and contextual AI integration*. Educators should integrate AI tools within inquiry-based and problem-solving pedagogies that cultivate critical and spatial thinking using locally relevant datasets and examples.
- *Build collaborative research and policy partnerships.* Collaboration among universities, government departments, and technology developers should be prioritised to co-create contextually relevant AI resources for Geography education.

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