

PGCE Students' Perceptions of Generative Artificial Intelligence within Learning Ecosystems at a South African Teacher Education Institution

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Abstract: The Fourth Industrial Revolution has brought artificial intelligence (AI) to the forefront of pedagogy in higher education institutions. However, limited empirical literature outlines students' perceptions of AI-powered learning in resource-poor environments of the Global South. **Methods** This study adopted an interpretive, mixed-methods, single-case design to investigate undergraduate students' perceptions of AI in their learning ecosystems. A purposive sampling approach was used to purposefully select 88 students taking the ICTs in Education class at a South African higher education institution. All the data collected in this study were based on one comprehensive research questionnaire that included both fixed-response Likert items and open-ended questions. The survey instrument elicited students' general perceptions about AI and their experience in a course activity where the task was to prompt AI to develop lesson plans, produce media products (posters, games, or videos) and create digital assessment activities. Results show that AI emerged as a powerful digital mediational artefact within the integrated conceptual framework that combines the principles of Vygotskian sociocultural theory and the ConTIS Model. 75% of respondents said that AI-based tasks made them feel more personalised and confident in the process of learning in their Zone of Proximal Development. However, there are several obstacles to AI-driven transformation. Socio-material limitations in the region, particularly data poverty and load shedding, constantly hinder the continuity of AI interactions, in addition to teachers' lack of competence in using AI tools (68%) and data privacy issues (61%).

Keywords: Artificial Intelligence, Fourth Industrial Revolution, Teacher Education, Personalised Learning, Student Perceptions, Digital Equity

1. Introduction

The Fourth Industrial Revolution (4IR) involves the fusion of digital, physical, and biological aspects and is creating revolutionary changes in society, the economy, and education across the globe (Schwab, 2016). As far as teacher education is concerned, AI has evolved from being merely an aspect of computing technology into a revolution in the way that institutions think, design, and teach (Zawacki-Richter et al., 2019). The current AI includes intelligent tutoring systems, adaptive learning, natural language processing, and automatic feedback (Holmes et al., 2019). Being central to the process of learning, AI holds importance for teaching, learning and institutions.

1.1 Rationale: Epistemic Gaps and Localized Fractures

Despite the incorporation of AI in universities at an unprecedented pace, gaps in the literature can be observed. The recent literature on educational technology after 2022 addresses AI generators or uses in institutions but does not mention students' experiences (Selwyn, 2019). Students are mostly passive consumers of the learning enabled by AI, leading to the marginalization of the epistemology of Global South higher education institutions (HEIs), which are characterized by diverse socio-economic conditions (Pedro et al., 2019). For optimizing Generation AI, the socio-economic conditions of these countries should be considered.

1.2 Problem Statement and Study Questions

The study addresses the empirical and contextual gaps through an exploration of Postgraduate Certificate in Education (PGCE) students' perceptions of AI-mediated learning in a South African teacher education institution. Through an emphasis on the subjective experience of students, the research aims to unravel PGCE students' perceptions of the role of Generative Artificial Intelligence (GenAI) in their learning ecosystems and to investigate the factors influencing their experiences of AI-mediated learning.

With a view to formulating a clear direction for the inquiry and answering the specific research problem, the study is informed by the following research questions: What perceptions do PGCE students hold regarding AI's role within their learning ecosystems? What are the complex factors that influence these experiences? Answering the research questions will provide much-needed empirical information for the development of curricula and policy frameworks for sustainability.

2. Literature Review

2.1 The Post-ChatGPT Landscape of AI in Teacher Education

The rapid diffusion of GenAI in the public domain has prompted a worldwide scholarly reaction. Kasneci et al. (2023) posit that GenAI represents a paradigmatic change from rule-based educational technology, allowing dynamic and situational interaction and transforming teacher-learner dynamics. From the perspectives of cognitive and computer science, Kasneci et al. (2023) provide a taxonomy of the capabilities and limitations of Large Language Models (LLMs), with an emphasis on dynamic content creation, automatic formative feedback, and tutoring intelligence. Crompton and Burke (2023) conduct a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)-compliant review of 138 articles (2016-2022) and find that AI in teacher education has been growing exponentially before ChatGPT, with volumes doubling or tripling in 2021-2022. The baseline has been established for GenAI-era growth. Traditional AI operates through rules or patterns. In contrast, GenAI synthesizes original text or media.

Kasneci et al. (2023) agree that current LLMs can generate real-time, context-sensitive responses that can mimic dialogic tutoring. Crompton and Burke (2023) reach the same conclusion and add that AI has moved from predictive analytics to pedagogy. However, there exists uneven optimism. Kasneci et al. (2023) appeal for moderation and caution with risks such as misinformation or "hallucinations", overreliance, cognitive atrophy, and pedagogical supervision needed. Again, Crompton and Burke (2023) highlight the scope of the research (pre-2023). Addressing the research gaps, the current paper collects qualitative data from 88 PGCE students in South Africa.

2.2 GenAI as an Enabler of Personalised Learning and Engagement

The use of GenAI in teaching involves personalization. Kasneci et al. (2023) posit that AI can give real-time, high-quality, personalized feedback that is adapted to the learner's ability to scaffold and use appropriate language. In all cases, timely and non-judgmental feedback results in learner autonomy and empowerment. Since feedback by AI is objective and iterative, it is perceived as stress-relieving and allows for trial and error (Miao & Holmes, 2023). However, opinions vary. While Miao & Holmes (2023) believe that personalization requires national infrastructures and teacher training, Kasneci et al. (2023) think that personalization is a matter of the individual, whose success will depend on previous knowledge and may create gaps.

Many studies assume a universal digital infrastructure in terms of the availability of the Internet and electricity at all times, but this is not true for the Global South. Miao & Holmes (2023) ignore the socio-material context, such as the cost of data and load shedding, making continuous dialogic scaffolding impossible.

2.3 Ethical, Institutional, and Equity Barriers to AI Integration

Implementation challenges in responsible GenAI in teacher education encompass several major integrity and policy issues. Cotton et al. (2023) name ChatGPT writing as one of the primary and hidden integrity concerns. Farrokhnia et al. (2023) develop a macro-Strengths–Weaknesses–Opportunities–Threats (SWOT) analysis that highlights issues with dishonesty, poor critical thinking, algorithmic bias, privacy risks, and decreased human autonomy. Chan (2023) develops an AI Ecological Education Policy grounded in 457 students and 180 institutional representatives from Hong Kong. Yan et al. (2024) confirm these obstacles through a systematic scoping review of 118 articles.

Inadequate policies are a recurring theme in the articles discussed. Farrokhnia et al. (2023) associate the integrity problem with the current status of assessment and call for policy changes and teachers' training, in addition to restrictions on GenAI. Holmes (2023) emphasises data ownership, transparency of algorithms, and human rights-orientated governance of learning.

Opinions about GenAI disruption differ. Cotton et al. (2023) perceive the issue as a governance problem; Chan (2023) perceives it as the future of education and supports AI-based assessment to promote higher-order thinking skills. Yan et al. (2024) recognise system barriers, such as model opacity and bias, as an ethical issue.

Context and geographical limitations exist. The above sources discuss highly resourced areas (the United Kingdom, Hong Kong, and Australia) and do not address such aspects as multilingualism, digital illiteracy, or socio-economic gaps typical for South Africa. Although Farrokhnia et al. (2023) provide a macro-SWOT approach, application to marginalised students is not provided.

3. Theoretical Framework

The research employs Vygotsky's theory of sociocultural constructivism and Constructivist Technology Integration Strategies (ConTIS) (Tunjera, 2019). AI is regarded as a situational and relational artefact in teacher education. AI is the mediational artefact which provides scaffolding in the process of cognitive and social activities in the Zone of Proximal Development (ZPD). For avoiding northern perspective, the research fits in with ConTIS and considers the digital transformation of TPACK. Constraints associated with data poverty may limit AI-based pedagogy and make it hard to move forward through the ZPD.

Figure 1 shows an integrated framework of this research placed at the intersection of Vygotskian Sociocultural Constructivism and ConTIS, and allowing socio-material analysis of AI-based learning in teacher education in relation to environmental factors impacting on learning effectiveness.

The socio-material core of the framework views AI as an artefact with its pedagogical value emerging from relations between learners, pedagogy, institutions and technologies. Furthermore, the environmental factors (material, socio-cultural and epistemic) that impact AI-based scaffolding and access are foregrounded. The material factors include devices, connectivity, data, and power; socio-cultural factors: language, norms, institutional support, and digital literacy; and epistemic factors: disciplinary background, curricula, and assessment. Digitally inequitable environments can hamper progress along the ConTIS trajectory towards Modification and Redefinition due to data poverty and connectivity.

Therefore, this socio-material framework is the basis of two-level analysis: (1) AI as scaffolding for learning and skill development and (2) structural and environmental factors facilitating or preventing equal access.

4. Research Design

This study employed an interpretative mixed-methods design with a single-case study framework to investigate how PGCE students make meaning of AI-mediated learning in a context-dependent manner (Creswell & Creswell, 2018). The scope of the study was limited to one group of PGCE students at a single higher education institution in South Africa, making the single-case study approach very appropriate for researching a current phenomenon in context (Yin, 2018). This study focused on collecting data using an open-ended and closed-ended questionnaire. This methodology aligns with interpretive paradigm guidelines, which prioritize understanding the subjective, lived experiences of participants within their natural settings (Creswell and Creswell, 2018; Merriam & Tisdell, 2016).

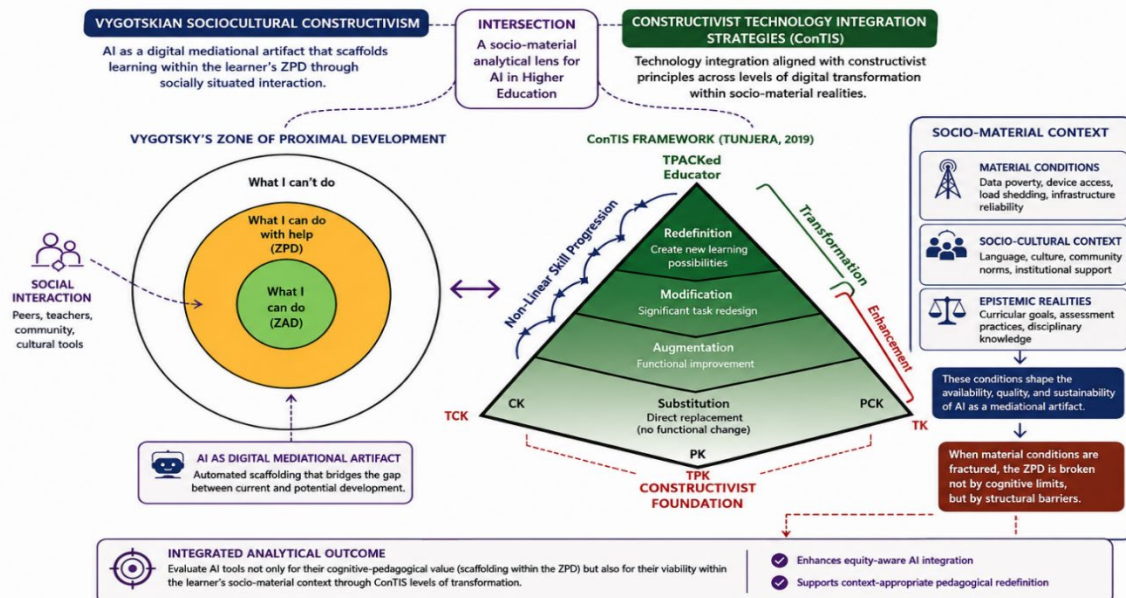


Figure 1: A socio-Material Lens for Evaluating Gen-AI in Higher Education, integrating Vygotskian ZPD and ConTIS

4.1 Participants

The participants comprised undergraduate PGCE students enrolled in a course on ICTs in education at a higher education institute in the Western Cape Province of South Africa. In this regard, a non-probability sampling design was used, which involved the use of both purposive and convenience sampling methods. The sampling design is purposive, as all respondents included in the study were purposely chosen because they were enrolled in the PGCE course and registered for the ICTs in Education module, which was essential for ensuring that participants had adequate baseline digital exposure and a theoretical framework to analyse AI as a mediational device. At the same time, the sampling design can be said to be a convenience one, as it made use of the available pool of individuals in the researcher's own institution.

4.2 Data Collection Instrument

A questionnaire was used to collect the data that would help achieve the objectives set by the study within the socio-material constructivist framework. In doing so, the integration of Likert Scales with broad open-ended questions helped in capturing both statistical and qualitative information from the 88 participants (Creswell & Creswell, 2018). Focus group interviews were conducted with fifteen PGCE students, who volunteered to be interviewed. The Focus Group Interview (FGI) complemented the questionnaire by making follow-up questions on the participants' perceptions of the AI-lesson development exercise.

4.3 Data Analysis

Both quantitative and qualitative methods were employed to analyse the data. Quantitative data obtained from 88 responses to the Likert scale survey questions were analysed using descriptive statistics in terms of frequencies and percentages. The qualitative data collected through open-ended questions and FGI were analysed thematically based on six steps outlined by Braun and Clarke (2006): familiarisation, coding, thematic development, reviewing, defining and reporting. Triangulation was applied sequentially in combining the datasets. Quantitative analysis revealed the overall pattern of perception about GenAI. At the same time, the FGIs were particularly useful in providing more explanations and experiences, as well as the socio-material aspects influencing AI-enabled learning. Triangulation involved the process of interpretation, whereby comparison was done between themes in qualitative data and trends in quantitative data in terms of convergence and divergence.

4.4 Ethical Clearance

Ethical approval for the study was obtained from the research ethics committee of the institution. The researcher shared the research information verbally and in writing. The participants were informed that participating was voluntary, anonymous, and written informed consent was obtained, which was incorporated in the instruments.

5. Findings

5.1 Demographic Composition of the Participant

The study was conducted with 88 PGCE participants enrolled in the ICTs in Education module. Table 1 shows the participants' characteristics: 65 females (73.9%) and 23 males (26.1%). Most of the participants were living at home (70.5%), 19.3% in university residences, and 10.2% in privately rented homes close to the institution. The relevant socio-material features that influence AI adoption have been identified. All the participants had smartphones; 86.4% owned personal laptops, and 13.6% used borrowed computers. Out-of-institution Internet connections depended mostly on mobile internet (77.3%), compared to institution Wi-Fi (13.6%) and personal home connection (9.1%). There was a high degree of language diversity, with the highest percentage of isiXhosa (65.9%) speakers, followed by English (9.1%), Afrikaans (8.8%) (refer Table 1),

Table 1: Demographic profile of participants (N=88)

Variable	Category	n	%
Gender	Female	65	73.9
	Male	23	26.1

Variable	Category	n	%
Living arrangement	Commute from home	62	70.5
	Private accommodation	9	10.2
	University residence	17	19.3
Primary device ownership	Smartphone	88	100.0
	Personal laptop	76	86.4
	Shared computer	12	13.6
Primary off-campus internet access data/Wi-Fi	Mobile	68	77.3
	Campus	12	13.6
	Home	8	9.1
Home language	English	8	9.1
	isiXhosa	58	65.9
	Afrikaans	10	8.8
	Other languages	12	13.6

5.2 AI an Academic Scaffolding Tool

Participants consistently described AI tools as valuable learning supports that assisted them in completing academic tasks, understanding complex concepts, and improving the quality of their work. Many students reported using AI to clarify difficult topics, generate examples, summarise academic readings, and receive immediate feedback on assignments.

On the reflection of GenAI in the lesson preparation activity, 90.1% of the participants indicated that more practice on prompting the AI enhanced their ability to create a more detailed and structurally sound lesson plan than they could have generated manually in the same timeframe. Figure 2.

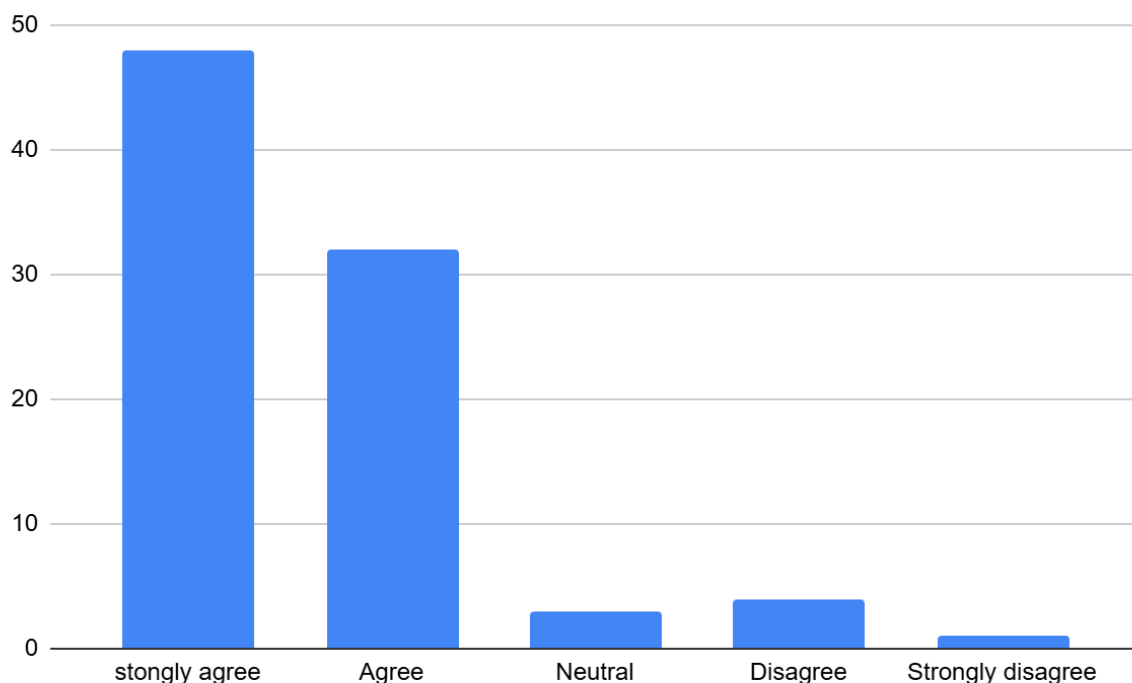


Figure 2: Prompting the AI helped refine their lesson plans.

Similarly, one participant from the FGI mentioned that using the AI prompted questions that helped her improve, and revision by adding areas that needed improvement. Several participants agreed that AI enabled them to work through learning and improving independently before seeking assistance from lecturers or peers. One participant reflected:

"When I get stuck, I ask the AI to explain the concept more simply. It helps me understand things before I go back to my notes."

The students reported that the usage of AI technology enhanced their confidence regarding unfamiliar concepts, appreciating the promptness of responses when no assistance was instantly available. Questionnaires revealed consensus on the notion that AI technology improved knowledge and facilitated self-learning.

5.3 AI-Enhanced Learning Efficiency and Productivity

A second prominent theme concerned the perceived efficiency gains associated with AI use. Participants reported that AI reduced the time required to search for information, generate ideas, structure assignments, and revise academic work. The participants' responses to the AI enhancement of learning efficiency and production were positive, with 89% agreeing to reveal a positive sentiment, with 11% having negative sentiments. Figure 3.

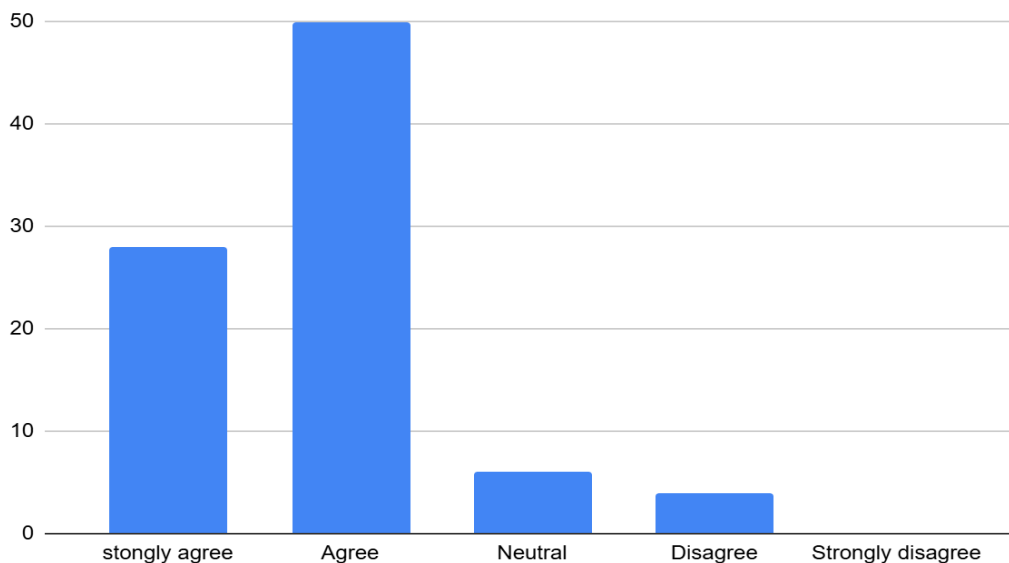


Figure 3: AI enhancement of learning efficiency and production

Many students described AI as helping them organise their thinking and initiate writing tasks that they would otherwise find difficult to begin. Reflective journal entries revealed that AI-assisted brainstorming was particularly beneficial when preparing essays, lesson plans, and research-related activities. One participant stated:

"Sometimes the hardest part is getting started. AI gives me ideas and a structure that I can build on."

The students indicated that the benefits of using AI included assistance in revision through summaries, quizzes, and simple explanations, thereby leaving more time to engage with the content. Even though the efficiency of using AI was recognized, most used their own judgment in evaluating AI products.

5.4 Tensions Between Support and Academic Integrity

Although the purported benefits of artificial intelligence (AI) are many, students voiced apprehensions over the reliance on content generated through AI and its ramifications for learning. The students pointed out that AI can, in some cases, lead to passive learning when not used critically. One remarkable response to the related question was,

"I am distressed about the collection, use, and storage of my personal and academic information by AI learning platforms."

Every participant strongly agreed that they were uncertain about the lack of training and policies around data protection. Uncertainty was expressed by some students about what institutions expect with respect to AI in terms of the level of help permitted and the distinction between academic help and academic cheating. One such participant expressed this concern:

"Sometimes I am not sure how much AI is collecting from us, using it is too good for free. We use it because it helps, but there are no clear rules ... we agree anyway."

While conducting the FGI, the students were concerned about potential problems caused by artificial intelligence, such as false citations, false facts, and oversimplification of scientific terms. Most of the students focused on the importance of verifying the information obtained from GenAI.

5.5 Socio-Material Barriers to AI-Supported Learning

The major constraints raised by the participants are those of accessibility and infrastructure. There were many issues that the students faced that prevented them from using AI technologies regularly. Among these constraints, the cost of data was raised quite often, since the use of AI applications demanded a good internet connection and, therefore, became difficult for poor students. One of the participants said that:

"AI is useful, but if you don't have data, you cannot use it when you need it."

Other barriers included those pertaining to poor internet connectivity, constraints due to hardware, and electricity failures. Such barriers would disrupt their ability to learn and interact with the AI systems. The students who came from deprived backgrounds faced more obstacles in accessing the AI learning experiences consistently. In comparison, those students who had internet access and devices felt that they were using AI systems frequently. Through the survey, participants highlighted their worries regarding access barriers to AI resources for different students. They believed that differences in infrastructure could result in the creation of inequalities in AI-mediated learning experiences and grades.

5.6 Conditions Supporting Sustainable AI Adoption

The following are some of the factors that were highlighted by the respondents as being very vital in increasing the effectiveness and sustainability of AI in teacher education. The factors included institutional guidelines concerning AI, training, low-cost Internet, better technology infrastructure, and policies of assessment.

The students expressed their desire to receive institutionalized support from the university to be able to develop skills concerning AI literacy. Many respondents advocated for the incorporation of AI in teaching and learning instead of considering AI just as another technological tool. According to one respondent:

"...Universities should teach us how to use AI properly because it is already part of how people learn and work."

Equitable access to digital sources was considered equally important in order for AI technologies to benefit all learners regardless of their socioeconomic status. According to the results, students find artificial intelligence useful as an aid in understanding and improving the efficiency of their studies, making learning more appealing. Nonetheless, the benefits associated with the use of AI technologies are subject to issues such as academic dishonesty and, even more importantly, socio-material access to digital technologies.

6. Discussion

In this research, an exploration of PGCE students' perceptions and experiences regarding the use of AI-enhanced learning in the South African higher education system is undertaken. It was found that most students perceive AI as an effective means to support the learning process and increase learning efficiency and independence, while at the same time posing academic integrity risks and socio-material barriers. Through interpretation using the combined Vygotskian-ContIS model, the complexity of the connection between the learning potential enabled through the use of AI and conditions of its actualization can be seen.

6.1 AI as a Digital Mediational Artifact within the Zone of Proximal Development

Results indicate that learners perceive GenAI as a support system for comprehension, problem solving, and self-regulated learning. The students use AI to understand concepts, receive feedback, and get guided learning without any help from humans (Kasneji et al., 2023; Luckin, 2024). This notion corresponds to Vygotsky's theory of socially mediated learning and tools.

Students regard AI as a digital mediational tool within the ZPD of the learner that can assist with activities and concepts that lie beyond their current capability. Thus, AI assists rather than replaces human learning by offering timely explanations, feedback, and instructions to overcome difficult concepts and challenges (Holmes et al.,

2022; Luckin, 2024). The PGCE students do not see AI as a replacement for learning but rather as an additional tool of knowledge acquisition.

6.2 AI Adoption Across the ConTIS Transformation Continuum

Findings show unequal AI adoption through different levels of ConTIS. Learners initially adopted AI in accomplishing simple tasks such as explanations, summaries, grammatical corrections, and outlining, implying substitution and augmentation (technologies enhancing yet not fully transforming learning). However, more transformative usages came up: using AI for idea generation, perspectives, lesson creation, and iterative learning. Application of redefinition was less common yet noticeable: some learners utilized AI for tailoring engagement, crafting personalized content, and feedback loops beyond traditional means. Most participants continued to be in the level of Substitution-Modification, not Redefinition, in keeping with ConTIS theory since technologies alone do not bring change; pedagogy matters. As pointed out by Tunjera (2019), teachers should allow learners to achieve transformative TPACK during class activities.

6.3 Socio-Material Constraints and the Fragility of AI-Mediated Learning

The socio-material constraints impede students' engagement with AI. The participants encountered barriers such as data cost, connectivity issues, device limitations, and load shedding. AI should be understood in terms of material context and not pedagogical or technological alone (Czerniewicz et al., 2020; Selwyn, 2022).

The combination of Vygotsky's theory with ConTIS emphasizes the constraints of AI. Although AI can function as a mediator in the ZPD, its mediation is based on access. Disruptions caused by connectivity challenges, high data cost, or load shedding lessen the scaffolding.

The findings add to the sociocultural theory by emphasizing that mediation of the learning process via AI is dependent on the materiality of the environment. Access disruptions affect the ZPD of learners, not because of any limitations of their cognition, but material limitations to access AI continuously. It is consistent with the socio-material approach to AI (Selwyn, 2022).

6.4 Digital Equity and AI Adoption in the Global South

These findings impact our comprehension of digital equity in Global South universities. The respondents appreciated the power of GenAI but mentioned that the benefits are unevenly distributed. Those students who had good internet connections, personal devices, and enough money engaged in using AI tools more often than those who were poor, and this is evidence of AI inequity that transcends the traditional digital divide (Selwyn, 2022). AI-powered education involves the use of technical equipment and internet connection, and its quality becomes another equity aspect in this case, since poorer students might face extra obstacles to AI learning.

The present study contributes to the existing literature that warns against making general assumptions about AI usage and success, as most of the research into AI in education is conducted in a technologically privileged environment (Selwyn, 2022). Therefore, digital equity must include equitable participation of students in AI learning processes. To do that, some institutional measures have to be considered.

6.5 Implications for Higher Education Policy and Practice

HEIs should use AI as a tool for transforming the pedagogy. In line with the principles of the ConTIS model, the most beneficial educational impact can be achieved when AI is used for fostering constructivism, collaboration, critical thinking and knowledge construction rather than for automation of some academic work. It can be said that there is a huge potential for AI to improve learning and teaching in higher education. To realize this potential, the intricate interrelation between technology, pedagogy, and socio-material conditions is required.

6.6 Limitation

The paper brings context-specific lessons regarding the integration of artificial intelligence in higher education institutions in the Global South, with certain limitations. Firstly, the paper employs only one case study from South Africa and therefore may not be generalized for other universities in the Global South, which may have different technological infrastructure and demographic characteristics. Secondly, the data used for empirical analysis are obtained via questionnaires, focus group discussions, and participants' diaries, which means that the data are open to the subjectivity of perception since direct observation of the prompting was not possible. Lastly, students were free to use any AI platform to generate content and evaluate it.

7. Conclusion

This research explored the experiences and perceptions of AI-mediated learning amongst PGCE students in a South African university environment. It emerged from the findings that, while AI is viewed as a tool for fostering understanding, self-learning, and academic productivity by the participants, there are certain social material conditions under which AI offers educational value. Based on Vygotskian sociocultural constructivism and ConTIS theory, the current study proposes that AI is a mediating digital artefact that can facilitate learning and assist in the process of transforming the learning experience. However, it is shown that the lack of access to adequate amounts of data, poor connectivity, limited device capacity, and load shedding are some of the factors that prevent students from accessing these benefits. In other words, this study shows that using AI in higher education can significantly enhance teacher preparation programmes. At the same time, the effectiveness of its use cannot be measured solely in terms of technological feasibility but requires an examination of pedagogy and other aspects of student life within the institution.

Ethics Declarations

This research was conducted with full ethical clearance from the institutional research ethics committee at the University of Technology. All participation was voluntary, anonymous, and based on written informed consent. No identifying information has been used in the reporting of findings.

AI Declaration

AI tools were used in the preparation of this paper to assist with structural drafting and language editing. All analytical decisions, theoretical interpretations, and empirical findings are the sole responsibility of the authors. All AI-assisted content was reviewed, verified, and substantially revised prior to submission.

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