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Revolutionizing Mathematics Education: Artificial Intelligence Integration, Ethics, and Access in Open Distance e-Learning

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ABSTRACT

Purpose: This study explores the integration of artificial intelligence (AI) tools in mathematics education within Open Distance e-Learning (ODeL) environments, focusing on barriers to access, ethical considerations, and pedagogical enhancement. The research addresses challenges such as digital inequities, inadequate devices, and institutional policy gaps. **Method:** A qualitative case study design was used, employing a structured survey to collect data from 78 students enrolled in a mathematics education module at a South African ODeL institution. The survey combined quantitative and open-ended qualitative questions to examine students' experiences with AI tools. Thematic analysis was applied to identify key challenges and potential strategies for improvement. **Findings:** Significant barriers to AI integration were identified, including unstable internet connectivity, limited access to suitable devices, and insufficient institutional support. These challenges disproportionately impacted students in rural and under-resourced areas. Despite these obstacles, students expressed enthusiasm about using AI tools, recognising their potential to simplify complex mathematical concepts, enhance engagement, and improve learning outcomes. Respondents highlighted the need for targeted training and structured curriculum integration to maximise AI's benefits. **Implications for Research and Practice:** Addressing digital inequities, enhancing digital infrastructure, and providing targeted training programs for students and lecturers are crucial for optimising AI integration. Institutions must develop clear ethical guidelines and embed Institutions-aligned AI tools into the curriculum to align technology use with pedagogical goals. Future research should explore AI adoption in diverse educational contexts and its long-term impacts on teaching and learning.

Introduction

Artificial Intelligence (AI) is revolutionising education globally, offering innovative solutions to long-standing challenges in teaching and learning. In mathematics education, AI tools such as ChatGPT, GeoGebra, and other generative platforms have demonstrated

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their ability to personalise learning, simplify complex concepts, and foster critical thinking (Maity & Deroy, 2024; Tilepbergenovna, 2024). These advancements are particularly valuable in Open Distance e-Learning (ODeL) contexts, where diverse learner needs and resource constraints demand flexible and effective pedagogical strategies (Xu, 2024). Despite the transformative potential of AI, systemic barriers hinder its integration in South African ODeL environments. These include persistent digital inequities, unreliable internet connectivity, limited device access, and inadequate institutional policies to support AI adoption. Such challenges disproportionately impact students in rural and under-resourced areas, perpetuating educational inequities (Dlamini, 2023; Guimaraes et al., 2024). Mathematics education, a foundational STEM discipline, is particularly affected, with students struggling to grasp abstract concepts and misconceptions persisting due to inadequate teaching resources (Ferreira, 2024).

Globally, the integration of AI in education is accelerating, driven by the need to modernise teaching practices and address diverse learner needs. Empirical studies underscore the transformative potential of AI tools. For example, Canonigo (2024) highlights how AI platforms like ChatGPT enhance students' conceptual understanding and engagement in mathematics, while Xu (2024) demonstrates the role of AI in providing adaptive feedback and supporting differentiated instruction in ODeL environments. Such tools can significantly improve teaching presence by automating routine tasks and cognitive presence by fostering inquiry-based learning (Garrison et al., 1999; Yang, 2024).

However, applying AI in resource-constrained settings such as South Africa's ODeL institutions remains underexplored. Studies by Makumane et al. (2023) and Guimaraes et al. (2024) reveal that digital inequities, unstable internet connectivity, high data costs, and limited device access are significant barriers to AI adoption. For instance, while smartphones are widely used, their limited computing capabilities often hinder engagement with complex AI tools required for mathematics education. This is compounded by the failure of iinstitutions of higher learning to provide resources and policies that align with the rapidly evolving digital landscape (Pule & Raxangana, 2024). Adding to these challenges are ethical concerns, including data privacy, algorithmic bias, and the potential over-reliance on AI tools. Farooqi et al. (2024) emphasise the importance of ethical frameworks to guide the responsible use of AI in education. The absence of structured training programs for students and lecturers further compounds these issues, as highlighted by Patel and Ragolane (2024). Educators struggle to integrate AI tools effectively without proper support, and students fail to realise their full potential.

In South Africa, mathematics education faces additional challenges due to systemic resource distribution and pedagogical support inequalities. Dlamini (2023) identifies rural students as disadvantaged, noting that poor connectivity and lack of devices exacerbate educational inequities. These barriers limit access to quality learning resources and hinder the adoption of innovative teaching practices that could address misconceptions and improve conceptual understanding (Canonigo, 2024). This study builds on the Community of Inquiry (CoI) framework, which emphasises the interplay of teaching, cognitive, and social presence in fostering meaningful learning experiences (Garrison et al., 1999). Empirical evidence from Yang (2024) and Bettayeb et al. (2024) demonstrates how AI tools can enhance these dimensions by promoting collaborative learning environments and supporting personalised feedback. The study highlights how AI tools can address mathematics education's pedagogical, cognitive, and social dimensions in ODeL settings

by situating the research within this framework. It also aligns with ongoing critical debates on leveraging AI to bridge educational inequities and enhance teaching and learning practices in diverse contexts (Makumane et al., 2023).

This study investigates how AI tools can be effectively integrated into mathematics education to enhance learning outcomes in South African ODeL environments. Specifically, it seeks to: 1) Identify barriers to AI adoption in mathematics education, 2) Assess students' experiences and perceptions of AI tools, and 3) Propose strategies for ethical and effective AI integration. The rationale for this study stems from the critical need to address these systemic challenges and explore how AI tools can enhance learning outcomes in mathematics education within ODeL contexts. By focusing on barriers to access, ethical considerations, and the alignment of AI with pedagogical goals, this research contributes to the growing discourse on equitable and effective technology integration in education.

The findings from this research aim to provide actionable insights into integrating AI tools in mathematics education, addressing both systemic and individual barriers to adoption. These barriers include digital inequities such as limited internet connectivity, inadequate devices, high data costs, ethical concerns related to privacy and algorithmic bias, and insufficient institutional support, including lack of training programs and curriculum alignment. By proposing targeted interventions and ethical guidelines, the study seeks to contribute to developing inclusive and effective educational practices in South African ODeL environments.

Literature Review

Artificial Intelligence (AI) has become a transformative force in education, offering innovative solutions to challenges in teaching and learning. Tools such as ChatGPT, GeoGebra, and other generative AI platforms demonstrate significant potential to enhance mathematics education by personalising learning, fostering critical thinking, and addressing complex concepts (Maity & Deroy, 2024; Tilepbergenovna, 2024). These advancements align with calls for innovative pedagogical strategies and context-based teacher development, particularly in STEM disciplines where mathematics forms a critical foundation (Ferreira, 2024; Rane et al., 2024).

Opportunities for AI Integration in Mathematics Education

AI tools offer considerable opportunities for addressing educational inequities, particularly in Open Distance e-Learning (ODeL) contexts. In mathematics education, where abstract concepts and misconceptions often impede student understanding, AI tools can provide real-time feedback, adaptive learning pathways, and personalised support (Xu, 2024). Such tools enhance conceptual understanding and enable differentiated instruction tailored to individual learner needs. This is particularly relevant in ODeL institutions, where students often juggle academic, professional, and personal commitments (Xu, 2024). Furthermore, AI-driven tools can modernise mathematics teacher training. By equipping pre-service teachers with the skills to use AI technologies, institutions can enhance pedagogical practices and ensure teachers are prepared to meet the evolving demands of digital classrooms. Globally, studies have highlighted AI's potential to improve student outcomes and support innovative teaching practices;

however, its application in South African ODeL settings remains limited and underexplored (Makumane et al., 2023).

Challenges to Effective AI Adoption

Despite its promise, the integration of AI in ODeL environments faces numerous challenges. Foremost among these is the persistent digital divide, disproportionately impacting students in rural and under-resourced areas. Many students lack access to stable internet connections and appropriate devices and rely heavily on smartphones, which are often insufficient for engaging with AI tools. High data costs and unreliable connectivity further exacerbate these inequities, limiting students' ability to participate fully in AI-enhanced learning opportunities (Guimaraes et al., 2024; Xu, 2024). In addition to infrastructural barriers, the absence of clear institutional policies and ethical guidelines poses significant challenges. Data privacy concerns, algorithmic bias, and over-reliance on technology are critical issues that remain unaddressed in many higher education contexts. The lack of structured training for both lecturers and students further reduces the efficacy of AI integration, with many educators reporting insufficient institutional support for embedding these tools into their teaching practices (Kujundziski & Bojadjiev, 2024; Vlasenko et al., 2022).

Role of Blended Learning in Mitigating Challenges

Blended learning, which combines synchronous and asynchronous modalities, has emerged as a viable strategy for addressing some of the challenges associated with AI adoption. For instance, live webinars and recorded lectures can bridge the gap for students in remote areas, offering flexibility and scalability. However, the success of blended learning models depends heavily on investments in digital infrastructure, offline-compatible resources, and targeted initiatives to ensure equitable access to AI tools (Makumane et al., 2023).

Bridging Institutional Gaps

Institutional gaps remain a critical barrier to meaningful AI adoption in South African ODeL environments. Many universities lack the frameworks to integrate AI tools effectively into their curricula. Lecturers often cite insufficient training and inadequate technical support as key obstacles, while students highlight the need for more explicit guidance and alignment of AI tools with academic objectives (Funda & Piderit, 2024; Tarisayi, 2024). Addressing these gaps requires systemic interventions, including investments in digital equity, lecturer professional development, and aligning AI tools with educational goals (Ferreira, 2024; Tang et al., 2024).

Towards Ethical and Equitable AI Use

For AI tools to achieve their transformative potential, institutions must prioritise ethical and equitable practices. Developing comprehensive guidelines for responsible AI use is critical to mitigating algorithmic bias and over-reliance (Yang, 2024). Yang (2024) further states that embedding AI into the curriculum in a structured and purposeful manner can help students and lecturers understand its relevance and applications. Foundational training is also essential to building digital literacy, ensuring that students and educators

can engage effectively with these tools. Institutions must address systemic inequities by enhancing digital infrastructure, offering device loans, and reducing data costs, enabling all students to benefit from AI-enhanced learning opportunities (Bettayeb et al., 2024; Makumane et al., 2023).

Theoretical Framework

This study is grounded in the Community of Inquiry (CoI) framework, developed by Garrison et al. (1999), which provides a robust model for understanding and optimizing learning experiences in online and blended environments. The CoI framework focuses on three interdependent elements, teaching presence, cognitive presence, and social presence, that collectively foster meaningful and collaborative educational experiences. This theoretical approach is particularly relevant to this study's focus on integrating generative AI tools within an Open Distance e-Learning (ODeL) context, where effective engagement and interaction are essential to student success. The CoI framework provides a comprehensive lens for examining the pedagogical, cognitive, and social dimensions of AI integration in education.

First, pedagogical dimension is the foundation of effective learning and involves designing, facilitating, and directing instructional processes to achieve educational goals (Anderson et al., 2001). This study reflects pedagogical dimension in integrating AI tools into the curriculum and providing structured training and support for their ethical and effective use. For example, workshops and clear institutional guidelines proposed in the findings aim to enhance teaching presence by equipping lecturers and students with the skills and resources to use AI tools responsibly. Second, cognitive dimension refers to how learners construct and confirm meaning through critical reflection and sustained inquiry (Garrison et al., 1999). Generative AI tools like ChatGPT support cognitive presence by simplifying complex mathematical concepts, providing immediate feedback, and fostering critical thinking. This study explores how these tools can enhance students' ability to engage deeply with learning materials, ensuring they are active participants in their learning process rather than passive consumers of AI-generated content. Third, social dimension involves the ability of learners to establish a sense of connection and collaboration within the learning community (Garrison et al., 1999). In an ODeL context, where students often face isolation, social presence can be undermined by digital inequities and limited interaction. The findings emphasise addressing these challenges by improving digital infrastructure, ensuring equitable access to AI tools, and fostering a collaborative learning environment where students can interact meaningfully with peers and instructors.

In this study, the CoI framework aligns to optimize the use of generative AI tools to enhance mathematics education. By focusing on pedagogical, cognitive, and social dimensions of AI integration in education, the study highlights how AI tools can create equitable and impactful learning experiences, particularly in resource-constrained ODeL settings (Garrison, 2016; Shea & Bidjerano, 2009).

Methodology

Research Design

This study adopted a qualitative case study design to explore integrating artificial intelligence (AI) tools in a mathematics education module within an Open Distance e-

Learning (ODeL) environment. The case study approach was chosen to provide an in-depth understanding of students' experiences and challenges related to AI tool adoption (Stake, 1995; Yin, 2003). The study was framed within an interpretive paradigm, emphasising participants' perspectives and the contextual factors influencing their engagement with AI tools (Creswell & Creswell, 2018).

Research Sample

The sample comprised 78 students enrolled in a mathematics education module at a South African ODeL institution. These students represented approximately 25.5% of the 306 active students in the module. As shown in Figure 1, 62.8% of the respondents were from rural areas, highlighting the prevalence of connectivity and infrastructure challenges among this group. This distribution provided valuable insights into the barriers and opportunities for AI tool integration in resource-constrained settings. The diverse backgrounds of the respondents further enriched the analysis by reflecting the realities faced by ODeL learners in different geographical and socio-economic contexts.

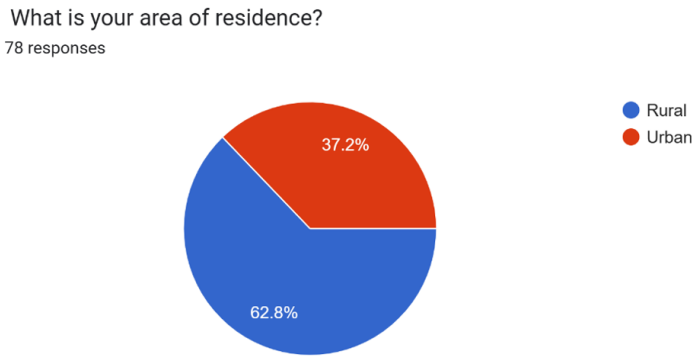

Figure 1: Distribution of Participants by Geographical Area

Research Instrument and Procedure

Data were collected using a structured Google Form survey to explore students' familiarity with and use of generative AI tools, such as ChatGPT, within one of the mathematics education modules (ACI2604). The survey was divided into five key sections: demographic information, device and connectivity access, digital tools and accessibility, engagement with university platforms, and perceptions of generative AI tools. This structure allowed for a comprehensive understanding of the challenges and opportunities related to AI tool integration. Quantitative items included questions about age, geographical location, internet connectivity (e.g., stable, unstable, or no access), and device availability (e.g., laptop, tablet, or smartphone). As shown in Figure 1, 62.8% of respondents were from rural areas, where connectivity challenges such as unstable internet access are prevalent. Qualitative open-ended questions asked students to suggest how the university could support AI tool adoption, including: "What support do you think the university should provide to help you use AI tools effectively?" and "Do you have any suggestions for how the university could better assist you in integrating these tools into your studies?"

Ethical clearance was obtained before the survey was distributed. Students were informed about the voluntary nature of their participation, the confidentiality of their responses, and the strict adherence to ethical research guidelines. Anonymity was guaranteed by not retaining personal information, as mentioned in the survey responses utilized exclusively for this study. These measures aimed to foster trust and encourage candid feedback from participants.

Data Analysis

Data analysis followed Braun and Clarke's six-step framework for thematic analysis. The process began with familiarisation, as the researcher carefully reviewed all responses. Open-ended responses were manually coded to identify recurring themes (Braun & Clarke, 2006). The recurring themes were refined into three key categories: "Support Needs for AI Usage," "Barriers to AI Integration," and "Student Recommendations for Institutional Support." Quantitative data, such as connectivity and device access statistics, were presented and summarised using descriptive statistics. Figure 1 visually illustrates the distribution of respondents by geographical area, highlighting the extent of digital inequities and connectivity issues. Strategies to ensure trustworthiness included cross-checking codes, providing detailed contextual descriptions, and practising reflexivity to minimise researcher bias.

Results

The findings highlight key challenges and opportunities in integrating AI tools within an Open Distance e-Learning (ODeL) environment, focusing on barriers such as digital infrastructure, platform engagement, and the need for structured curriculum integration and support.

Digital Infrastructure and Connectivity Needs

As illustrated in Figure 2, the survey findings reveal significant disparities in digital connectivity among students, showcasing the proportion of students grappling with connectivity issues. Of the 78 respondents, 66.4% reported having stable internet access, while 32.8% experienced unstable connectivity. A small but notable percentage (1%) indicated no internet access. These realities highlight many students' challenges in Open Distance e-Learning (ODeL) environments, particularly those in rural or underserved areas.

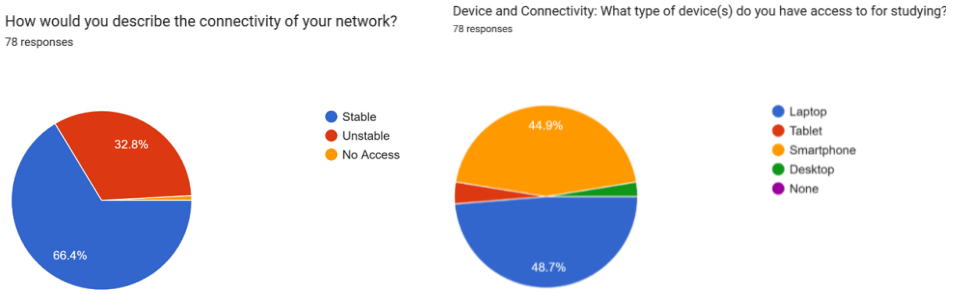

Figure 2: Connectivity and device access

Participation in the survey further reflects the influence of digital inequities. Despite the survey being open to all 306 students, only 25.5% responded. The remaining 74.5% who did not participate will likely include students from areas with poor network coverage or no access. Their absence in the data, as suggested by the low participation rate, hints at an underrepresentation of the most disadvantaged students. Many of these student's likely face barriers in completing surveys and accessing critical ODeL resources, a disparity visually supported by the network connectivity distribution in Figure 2.

Device access provides additional insights into students' digital environments. Nearly half of the respondents (48.7%) reported using laptops, while 44.9% relied primarily on smartphones. The remainder indicated access to tablets or desktops, with no students reporting a complete lack of devices. However, as depicted in Figure 2, the heavy reliance on smartphones suggests limitations in students' ability to engage with tools and platforms requiring robust computing capabilities. In mathematics education, where AI tools and complex problem-solving are critical, the use of smartphones presents constraints that may hinder effective engagement. These findings also highlight a broader systemic issue. Students with unstable or no internet access face significant barriers to engaging fully with ODeL platforms, including live webinars and asynchronous resources. Those relying on mobile devices, though partially connected, are constrained in their ability to leverage AI tools or navigate advanced tasks. These disparities bring into focus the urgent need to address the digital divide within ODeL environments.

Barriers to Platform Engagement

The survey responses reveal a range of challenges that hinder students' ability to engage effectively with the university's online platform, *myUnisa*. Figure 3 provides a comprehensive visual summary of the factors influencing students' limited engagement with discussion forums, offering valuable insights into the patterns and scope of these barriers. A significant proportion of students (44.9%) cited a lack of internet access as the primary obstacle. This issue was particularly pronounced among students in rural areas, were inadequate infrastructure compounds connectivity problems. One respondent expressed this frustration, stating, "*Since I'm staying in rural areas, the only solution to fix this problem is to install Wi-Fi.*" Device limitations were another frequently mentioned barrier, with 25.6% of respondents reporting inadequate access to suitable devices. Many students rely on smartphones, which, while useful for basic tasks, are often insufficient for navigating the complexities of academic platforms. As reflected in Figure 3, device limitations remain a persistent obstacle for many students. One student emphasized the need for better tools, stating, "*Laptop [access] is needed, as smartphones alone are not enough for completing tasks.*"

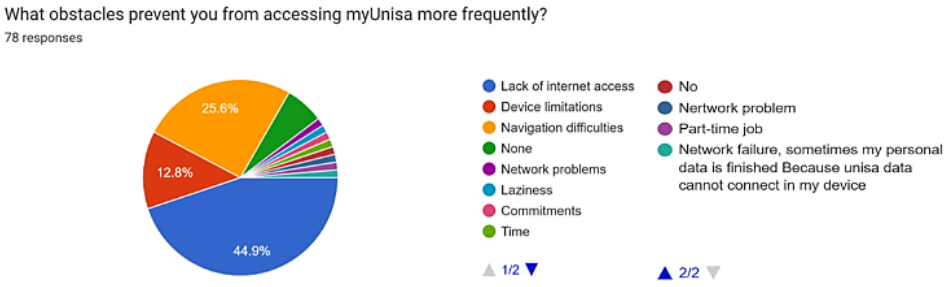

Figure 3: Barriers to Student Participation in Discussion Forums

Network instability, reported by 12.8% of respondents, added another layer of difficulty, particularly for those reliant on mobile data. One student noted, *"Network failure, sometimes caused by my personal service provider, prevents me from accessing my work consistently."* These connectivity-related issues are further exacerbated by the high cost of mobile data, which limits students' ability to stay connected for extended periods, a reality also highlighted in Figure 3. In addition to these structural challenges, personal barriers also emerged. Several students cited time management difficulties and competing responsibilities, such as part-time jobs, as significant obstacles to their engagement with *myUnisa.* One respondent remarked, *"Working and studying is hard, as well as time management."* These insights suggest that the dual burden of academic and professional commitments leaves little room for consistent platform access. Usability issues also surfaced, with some students pointing to navigation difficulties as a deterrent. As one student commented, *"Clearer instructions on how to use the platform would make it easier to access the information I need."* These concerns reflect the need for user-friendly design and better orientation resources to improve students' platform experience.

The barriers identified in the survey highlight a complex interplay of structural and personal challenges that limit students' engagement with the university platform. Structural issues, such as lack of internet access, device inadequacy, and network instability, perpetuate digital inequities, particularly for students in rural areas. Personal challenges, including time management and competing commitments, further exacerbate the problem, leaving some students unable to fully participate in their studies. These obstacles collectively illustrate the urgent need for targeted interventions. Equitable access to devices, reliable internet, and support for time management and platform usability are critical steps toward fostering inclusive engagement in Open Distance e-Learning (ODeL) environments.

Infrastructure and Access Challenges

The data reflects that students face significant infrastructural barriers that limit their ability to use AI tools effectively. The primary issue highlighted is network instability, particularly in rural areas. One student commented, *"In rural areas, the network is not stable,"* which points to a recurring challenge in Open Distance e-Learning (ODeL) environments. This instability impacts students' ability to engage consistently with online platforms and tools. Device limitations were also frequently mentioned, with students expressing the inadequacy of smartphones for academic tasks. One student stated, *"Laptop [access] is needed, as smartphones alone are not enough for completing tasks."* These responses underscore the necessity for devices that can handle the technical demands of AI tools and academic platforms.

Some students suggested institutional interventions, such as providing access to suitable devices, would help mitigate these challenges. Another student remarked, *"The university must provide a support system that can help us solve problems,"* indicating a need for technical support to address these barriers effectively.

Integration of AI into the Curriculum

Many students highlighted the need for a structured integration of AI tools into the curriculum. They expressed frustration over the lack of alignment between these tools and

academic objectives. One student suggested, *"Tailored curriculum development – integrate AI tools into specific courses, aligning them with the curriculum to enhance learning outcomes."* Others emphasized the value of practical engagement, proposing including AI tools in assessments and learning activities. For instance, one response stated, *"The university can give me exercises and assessments where I can use AI tools."* These comments reflect a desire for the tools to be embedded into coursework in a way that allows students to develop both practical and theoretical understanding. Such integration would not only help students familiarize themselves with AI tools but also ensure that their use is purposeful and aligned with the academic requirements of their courses.

Personalization and Real-Time Support

Students expressed the need for immediate and personalized support to navigate using AI tools effectively. One respondent remarked, *"The university must provide a support system that instantly replies to our problems 24/7, which can be AI,"* highlighting the importance of accessible, real-time assistance in an ODeL environment. Delayed responses from lecturers or institutional support staff were another source of frustration. A student noted, *"By responding to our emails in time,"* the university could significantly improve the learning experience by addressing challenges as they arise. This feedback suggests that personalized support systems, whether automated or human-led, are critical for enabling students to overcome technical and academic difficulties.

Building Familiarity with AI Tools

A recurring theme in the data was the lack of familiarity with AI tools and their applications. Students expressed a strong willingness to learn but acknowledged their limited knowledge. One student shared, *"I don't have much knowledge about these tools, but I am willing to take part,"* demonstrating openness to acquiring new skills. The feedback also highlighted the need for foundational training, with responses like, *"They should give us lessons on how to effectively use AI tools to prevent students from copying and pasting everything."* These comments emphasize the importance of introducing students to AI in a structured and responsible way, focusing on ethical use and critical engagement. Another respondent pointed to the need for clarity, stating, *"The university must help by making us understand these AI tools."* This reflects a gap in basic awareness and training that must be addressed to enable students to leverage AI for their studies entirely.

Discussion

This section interprets the findings considering the Community of Inquiry (CoI) framework and relevant literature, highlighting how the identified themes align with the theoretical dimensions of teaching presence, cognitive presence, and social presence. The discussion also situates the findings within broader scholarly discourses on AI integration in ODeL environments.

Digital Infrastructure and Connectivity Needs

This study revealed that unstable internet connectivity and limited access to appropriate devices, particularly in rural areas, significantly hinder students' ability to use AI tools in ODeL environments. As shown in Figure 2, 62% of respondents from rural areas

faced connectivity challenges, echoing findings from Xu (2024) and Guimaraes et al. (2024) that highlight the role of infrastructure in perpetuating digital inequities. These barriers undermine teaching presence or pedagogical dimension, a critical element of the Community of Inquiry (CoI) framework, by restricting access to instructional content and AI-supported activities. Guimaraes et al. (2024) argue that targeted policies addressing systemic inequalities, such as free access to Wi-Fi in underserved regions, are essential to support marginalized students and enhance their participation in AI-enabled learning environments. To address these issues, investments in expanding network coverage, providing affordable internet packages, and offering loan devices are crucial to bridging the digital divide and fostering equitable learning environments (Memon & Memon, 2025). As discussed by Makumane et al. (2023), blended learning models could serve as a practical solution to mitigate digital inequities, particularly for rural students.

Barriers to Platform Engagement

Students reported challenges navigating university platforms like *myUnisa*, with issues such as insufficient guidance, device limitations, and time management difficulties being prevalent. These findings align with Makumane et al. (2023), who emphasised the need for user-friendly platforms and structured training to enhance engagement. Limited engagement weakens cognitive dimension in the CoI framework by preventing meaningful reflection and inquiry. Addressing these barriers requires institutions to simplify platform interfaces, provide targeted user support, and integrate AI tools to enhance interactivity and usability, ensuring students can access and utilise available resources effectively.

Integration of AI into the Curriculum

Participants strongly desired institution-aligned AI tools to be embedded in the curriculum, emphasizing their potential to simplify complex mathematical concepts and enhance engagement. This aligns with Ferreira (2024) argument that AI tools must be purposefully integrated to align with educational objectives, optimizing their impact. The findings further illustrate how embedding institutionally vetted AI tools can enhance teaching presence by delivering structured, engaging instructional materials tailored to the curriculum. Integrating these tools into academic activities, such as problem-solving exercises and assessments, fosters more profound learning and equips students with skills for real-world applications. Achieving this, however, necessitates curriculum redesign that ensures AI tool usage aligns with specific learning outcomes, complemented by professional development programs to equip educators with the skills needed for effective and ethical implementation.

Personalisation and Real-Time Support

The need for real-time, personalised support emerged as a critical theme, with students calling for AI-driven systems to provide immediate assistance. This aligns with Bettayeb et al. (2024), who emphasised that responsive systems are vital for fostering student engagement in technology-enhanced learning. The CoI framework underscores the role of teaching presence in ensuring students feel supported throughout their learning journey. Combining AI-powered support systems with human-led interventions can address

technical and academic challenges, fostering an inclusive environment where students can navigate AI tools effectively and confidently.

Building Familiarity with AI Tools

A significant finding was students' lack of familiarity with AI tools despite their willingness to learn. Many participants highlighted the need for foundational training to build their digital literacy and ethical understanding of AI use. Research indicates that while many students utilize AI tools like ChatGPT, only a minority feel confident in maintaining the authenticity of their outputs, highlighting a critical need for structured training programs to enhance digital literacy and ethical understanding (Yang, 2024). As Zviel-Girshin (2024) and Ferreira (2024) advocate, structured training programs are essential for equipping students with the skills to engage critically with AI technologies. This theme aligns with cognitive dimension in the CoI framework, as building familiarity enables students to engage actively with learning materials and use AI tools as resources for inquiry and reflection. Institutions must prioritise training workshops and tutorials to address this gap and ensure students can leverage AI for meaningful learning.

Conclusion

This study examined the integration of artificial intelligence (AI) tools in a mathematics education module within an Open Distance e-Learning (ODeL) environment, highlighting critical challenges and opportunities. The findings revealed significant barriers, including unstable internet connectivity, limited device access, and insufficient familiarity with AI tools. A lack of curriculum integration and personalised, real-time support compounded these challenges. Guided by the Community of Inquiry (CoI) framework, the discussion demonstrated how these barriers undermine teaching, cognitive, and social presence, limiting students' ability to engage with AI tools effectively. Institutional interventions, such as enhancing digital infrastructure, offering targeted training programs, and embedding institution-aligned AI tools into the curriculum, are essential for effectively addressing these systemic and individual barriers.

This study contributes to the growing discourse on AI in education by proposing actionable strategies to address challenges specific to resource-constrained ODeL environments. It offers theoretical insights through the CoI framework, demonstrating how AI tools can strengthen teaching, cognitive, and social presence to foster meaningful learning experiences. The study highlights digital inequities and ethical concerns and underscores the need for structured workshops, clear institutional policies, and curriculum alignment to optimise AI integration. These findings provide a practical framework for enhancing technology adoption in education, advancing equitable and inclusive practices, and guiding future research on effective AI implementation in diverse educational contexts.

To enhance the integration of AI tools in Open Distance e-Learning (ODeL) environments, this study recommends prioritising improvements to digital infrastructure and accessibility. Institutions should collaborate with service providers and the government to expand network coverage, particularly in rural areas, and provide Wi-Fi access in underserved schools. Loaner devices, such as laptops, should be made available to address the limitations of smartphones for academic tasks and enable more effective

engagement with AI tools. Additionally, institution-aligned AI tools should be meaningfully embedded into the curriculum through assignments, tutorials, and assessments, ensuring their integration is purposefully aligned with academic objectives and learning outcomes. Training programs like workshops and tutorials should be introduced to build technical skills, foster critical engagement, and promote ethical use.

To address connectivity challenges, institutions should develop offline-compatible solutions, including downloadable content and offline versions of AI tools, to support students with unstable internet access. Personalised support systems, combining AI-powered tools with human-led assistance, should also be established to provide real-time guidance and foster a supportive learning environment. Clear ethical guidelines for AI use must be developed and communicated to reduce uncertainty and encourage responsible application. Regular monitoring and evaluation mechanisms, guided by student and lecturer feedback, are essential to iteratively improve AI adoption and maintain its relevance to educational needs.

Future research should expand its scope to include other ODeL modules and programs to provide a comprehensive understanding of AI integration across academic contexts. Investigating ethical concerns, such as data privacy and academic integrity, is critical to developing robust guidelines for equitable AI use. Mixed methods approach, such as interviews and classroom observations, should be employed to deepen insights into student experiences and strengthen the evidence base for effective AI adoption.

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