

TEACHING WITH TECHNOLOGY: LECTURER CHALLENGES IN ADOPTING AI TOOLS FOR STEM

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Abstract

This paper examines the challenges lecturers face when adopting Artificial Intelligence (AI) tools in STEM teaching at a South African private higher education institution. Using qualitative secondary analysis of interview, observation, and focus group data from a Master's study, the research re-analyses lecturers' experiences through Rogers' Diffusion of Innovation (DOI) theory. The findings identify key interrelated barriers, including student misuse, unreliable infrastructure, coding inaccuracies, academic integrity concerns, limited training, cautious lecturer attitudes, and increased workload. These challenges map onto DOI attributes, relative advantage, compatibility, complexity, trialability, and observability, highlighting that AI adoption is shaped primarily by systemic and institutional conditions rather than individual resistance. The study argues that sustainable AI integration in STEM requires reliable infrastructure, discipline-specific professional development, and clear ethical guidance, and offers contextually relevant recommendations for higher education.

Keywords: *Artificial intelligence, STEM education, diffusion of innovation, higher education, lecturer adoption.*

1. Introduction

The integration of Artificial Intelligence (AI) in higher education has accelerated due to its potential to enhance teaching through adaptability and efficiency. Within STEM education, AI is increasingly recognised as transformative, influencing both instructional design and student engagement (Xu & Ouyang, 2022; Ajayi, 2024).

Despite these opportunities, significant challenges remain. Concerns relating to data privacy, unequal access, and ethical use continue to shape AI adoption, alongside limited AI literacy among lecturers and students (Mahmud et al., 2024; Mah & Groß, 2024). Research indicates that adoption is influenced not only by individual perceptions but also by institutional conditions and social context (Perez, 2024).

In the South African context, digital transformation accelerated during the COVID-19 pandemic, exposing both opportunities and structural inequalities (Mhlanga et al., 2022). Ongoing challenges, including unreliable infrastructure and uneven professional development, continue to constrain the adoption of advanced technologies such as AI (Msila, 2022; Teane & Matlala, 2025). These conditions are further shaped by broader transformation imperatives, including responsiveness to the Fourth Industrial Revolution and decolonisation agendas (Turner, 2023; Samuels & Singh, 2025).

Against this backdrop, this study examines the barriers lecturers experience when adopting AI tools in STEM teaching within South African higher education. The research question guiding the study is: What barriers and challenges do lecturers face when adopting AI tools in STEM teaching within South African higher education?

The objectives are to:

1. Re-analyse lecturers' experiences of AI integration using existing qualitative data.
2. Interpret these challenges through Rogers' Diffusion of Innovation theory; and
3. Generate contextually relevant recommendations for ethical and sustainable AI adoption.

2. Literature review

The adoption of emerging technologies in higher education is commonly examined through frameworks that explain how innovations are accepted or resisted. Rogers' Diffusion of Innovation (DOI) theory is widely used to understand technology uptake within educational contexts, conceptualising adoption as a socially influenced process shaped by the perceived attributes of an innovation and the institutional environment in which it is implemented (Rogers, 2003; Currie et al., 2021).

In higher education, research shows that successful technology adoption depends not only on individual willingness but also on enabling institutional conditions such as leadership support, infrastructure, and professional development. Adoption is often non-linear and may be constrained by workload pressures, skill gaps, and concerns about pedagogical control (Buč & Divjak, 2015; Gonçalves & Pedro, 2012). These insights position DOI as a useful lens for examining AI adoption, which introduces both opportunity and uncertainty in teaching practice.

While alternative models such as the Unified Theory of Acceptance and Use of Technology (UTAUT) emphasise individual-level determinants, including perceived usefulness and ease of use (Venkatesh et al., 2003), DOI offers a broader perspective by capturing the interaction between institutional, pedagogical, and social factors.

Recent literature highlights both the potential and challenges of AI adoption in higher education. AI tools are associated with personalised learning and automated support, particularly in STEM contexts (Xu & Ouyang, 2022; Ajayi, 2024). However, adoption is constrained by infrastructural limitations, limited resources, and unresolved ethical concerns, including academic integrity and data privacy (Mah & Groß, 2024; Ojha, 2024).

Within the South African context, AI adoption reflects both innovation and inequality. While digital transformation has accelerated, adoption remains uneven due to infrastructural constraints, digital divides, and variable institutional support (Mhlanga et al., 2022; Funda & Mbangeleli, 2024). These conditions highlight the need for systemic approaches that extend beyond individual acceptance to include institutional readiness and contextual alignment.

Overall, the literature indicates that AI adoption in higher education is shaped by the interaction of individual perceptions, institutional conditions, and broader socio-cultural factors. DOI provides a suitable framework for examining how these dimensions converge to influence the adoption of AI tools in STEM teaching.

3. Theoretical framework

This study is underpinned by Rogers' Diffusion of Innovation (DOI) theory, which explains how new technologies are adopted within social and institutional contexts (Rogers, 2003). In higher education, DOI provides a useful lens for examining how lecturers engage with emerging technologies such as AI.

The theory identifies five attributes that influence adoption: relative advantage, compatibility, complexity, trialability, and observability. In the context of AI in STEM teaching, these attributes shape how lecturers evaluate the usefulness, alignment, and practicality of AI tools in their pedagogical practices.

This study applies DOI to examine how institutional, technical, and pedagogical factors influence lecturers' adoption of AI. Rather than treating adoption as a binary outcome, the framework enables analysis of how systemic conditions and individual perceptions interact to shape uptake.

DOI has been widely applied in educational contexts to analyse technology adoption in digitally transforming environments (Mbatha, 2024; Alka'awneh et al., 2025). Its focus on both organisational and social dynamics makes it particularly appropriate for examining the barriers to AI adoption in STEM teaching.

4. Methodology

This study employed a qualitative secondary analysis of data originally collected for a Master's study examining AI adoption in first-year STEM teaching at a South African private higher education institution (Govender, 2025). The analysis focused specifically on lecturers' experiences of challenges and barriers to AI adoption.

The dataset comprised semi-structured interviews, classroom observations, and a focus group involving five STEM lecturers with experience using AI tools in teaching. Data were transcribed, anonymised, and re-analysed using Rogers' Diffusion of Innovation (DOI) theory as the primary analytical framework.

The analysis was conducted using ATLAS.ti, with codes explicitly mapped to DOI attributes: relative advantage, compatibility, complexity, trialability, and observability.

Credibility was enhanced through triangulation across data sources and consistent pattern identification.

4.1. Ethical considerations

Informed consent obtained in the original study explicitly permitted future academic use of anonymised data. The present analysis was therefore conducted within the scope of those ethical approvals.

5. Findings

This section presents the key challenges lecturers experienced when adopting AI tools in STEM teaching at a South African private higher education institution. Based on a secondary analysis of interviews, classroom observations, and a focus group discussion, eight themes were identified and mapped to Rogers' DOI attributes. Table 1 summarises the themes, supporting quotations, and associated DOI constructs. Overall, lecturers reported persistent challenges related to student misuse of AI tools, unreliable technical infrastructure, inaccuracies in AI-generated content, limited institutional support, academic integrity concerns, and increased workload. These challenges influenced lecturers' confidence, willingness to experiment, and perceptions of AI's pedagogical value.

Student misuse of AI tools emerged as a compatibility concern, with lecturers noting that students often relied on AI outputs without critical engagement. Technical infrastructure limitations constrained opportunities for experimentation, reducing trialability and increasing perceived complexity.

Concerns regarding coding inaccuracies and the need for constant verification undermined the perceived relative advantage of AI use.

Lecturers further highlighted limited training and institutional guidance, which affected both compatibility and trialability. Cautious lecturer attitudes reflected uncertainty about the pedagogical implications of AI, particularly in relation to academic integrity. Finally, increased workload and time pressures diminished perceptions of efficiency, further limiting adoption.

Table 1. Summary of key themes and DOI alignment.

Theme	Description (Condensed)	DOI Attribute(s)
Student misuse of AI	Reliance on AI outputs without critical engagement	Compatibility
Technical infrastructure	Unreliable connectivity limits classroom use	Trialability, Complexity
Verification of AI output	Need to check and refine AI-generated content	Relative Advantage
Coding inaccuracies	Errors and outdated outputs increase difficulty	Complexity
Training and support gaps	Limited institutional guidance and professional development	Compatibility, Trialability
Lecturer attitudes	Cautious adoption due to pedagogical concerns	Compatibility, Relative Advantage
Academic integrity concerns	Plagiarism and superficial learning challenges	Observability
Workload pressures	Increased effort to manage and verify AI use	Relative Advantage

6. Limitations

As a secondary analysis, this study was limited to one thematic focus, challenges and barriers to AI adoption, from a broader dataset. The participant group was relatively small (five STEM lecturers from a single private higher education institution), which limits generalisability to other contexts. The findings should therefore be interpreted as contextually rich insights rather than universal conclusions.

7. Discussion

The findings indicate that while STEM lecturers recognise the potential pedagogical value of AI tools, adoption is constrained by systemic and pedagogical barriers. Interpreted through Rogers' DOI theory, these challenges reflect limited alignment with key innovation attributes, which collectively slow the diffusion of AI in higher education.

The perceived relative advantage of AI was undermined by increased workload pressures, particularly the need to verify and correct AI-generated outputs. Rather than enhancing efficiency, AI often introduced hidden labour, reducing its perceived benefit. However, where lecturers reframed AI outputs as learning artefacts for critique and discussion, relative advantage became more visible, suggesting that pedagogically informed integration can offset efficiency concerns.

Compatibility challenges were evident in student misuse of AI as an answer-providing shortcut, which conflicted with lecturers' goals of fostering critical thinking and academic integrity. These tensions

shaped cautious lecturer attitudes and selective adoption practices, reinforcing the importance of aligning AI use with established pedagogical values and ethical expectations.

Complexity further constrained adoption, especially in coding-intensive STEM contexts where inaccurate or outdated AI outputs increased the learning curve for both lecturers and students. Without targeted training and institutional support, these technical limitations heightened uncertainty and reduced confidence in AI use.

Trialability was limited by unreliable infrastructure and the absence of low-risk opportunities for experimentation. In line with DOI theory, restricted trial environments discouraged lecturers from investing time in exploring AI tools. Observability was similarly constrained, as lecturers struggled to determine whether AI use resulted in meaningful learning or superficial engagement. Although some educators addressed this through redesigned, critique-based assessments, the benefits of AI often remained difficult to demonstrate.

Taken together, these findings highlight that barriers to AI adoption in STEM teaching are not isolated technical issues but are embedded within broader institutional and pedagogical systems. DOI theory illustrates how deficiencies across multiple innovation attributes converge to impede diffusion. Addressing these challenges requires systemic interventions, including reliable infrastructure, discipline-specific professional development, and clear ethical frameworks to support sustainable and meaningful AI integration.

8. Recommendations

Based on the findings and informed by Rogers' DOI theory, the following recommendations are proposed to support effective and ethical integration of AI tools in STEM teaching within South African higher education.

First, institutions should enhance the relative advantage of AI by supporting pedagogically purposeful uses that reduce, rather than increase, lecturer workload. This includes professional development focused on AI-integrated lesson design and assessment practices where AI demonstrably improves efficiency, such as formative feedback and personalised learning support.

Second, AI adoption should be strengthened through improved compatibility and reduced complexity. Structured faculty development should extend beyond tool familiarisation to include ethical AI use, discipline-specific applications, and strategies to discourage superficial student reliance on AI outputs. Targeted support, particularly in coding-intensive STEM contexts, can build lecturer confidence and lower perceived barriers to use.

Third, institutions should improve trialability and observability by creating supportive environments for experimentation and knowledge sharing. Providing reliable digital infrastructure, low-risk pilot spaces, and communities of practice can enable lecturers to test AI tools safely and make successful practices more visible, thereby accelerating diffusion.

Collectively, these recommendations emphasise that meaningful AI adoption depends not only on technological access but on institutional readiness, pedagogical alignment, and ethical governance. By addressing key DOI attributes, higher education institutions can position AI as a catalyst for reflective and contextually relevant innovation rather than a source of uncertainty.

9. Conclusion

This study examined the challenges lecturers face when adopting AI tools in STEM teaching within a South African private higher education institution. Through a secondary analysis of interviews, focus groups, and classroom observations, key barriers were identified, including student misuse, infrastructural limitations, coding inaccuracies, academic integrity concerns, and limited institutional support. Interpreted through Rogers' Diffusion of Innovation theory, these barriers mapped onto limited relative advantage, poor compatibility, high complexity, restricted trialability, and weak observability.

The analysis demonstrates that AI adoption is not hindered by technological availability alone but by systemic, pedagogical, and institutional conditions. Addressing these challenges requires enhancing the perceived value of AI, ensuring alignment with curriculum goals, reducing complexity through training, enabling experimentation, and making successes more visible.

By grounding recommendations in DOI theory, this paper highlights the need for strategic, evidence-based interventions to ensure that AI integration is ethical, sustainable, and contextually meaningful in South African higher education. Ultimately, diffusion of AI in STEM will depend on institutions' ability to align technological possibilities with human capacities, pedagogical integrity, and the broader transformation goals of higher education.

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