
Teacher Innovation Through ICT Professional Development in Low-Resourced Primary Schools

Matjema Caroline Maeane ¹, Nokulunga Sithabile Ndlovu ²

^{1, 2} University of the Witwatersrand, Wits School of Education, South Africa

Abstract. Promoting teacher innovation through Information and Communication Technologies (ICT) Teacher Professional Development (TPD) in low-resourced primary schools remains a persistent challenge, shaped by systemic inequalities and resource constraints. This paper explores how ICT-TPD programmes can foster innovation in such contexts, focusing on a case study of a low-resourced primary school in Johannesburg, South Africa. A mixed-methods design was employed, with data collected from six teachers who participated in a structured ICT-TPD programme aimed at strengthening curriculum integration. The findings reveal that while teachers were motivated to innovate, barriers such as unreliable or unavailable devices, limited internet connectivity, and high workloads constrained sustained adoption. Some teachers demonstrated agency by independently acquiring devices, while others struggled to maintain consistent engagement, underscoring the need for differentiated support. Grounded in the Diffusion of Innovation (DOI) framework, this study extends the model through a proposed **DOI-plus**, which incorporates contextual sustainability as a sixth attribute reflecting systemic and infrastructural conditions beyond individual control. The study argues that ICT-TPD must be context-sensitive, adaptable, and designed to provide ongoing support and opportunities for experimentation. Such approaches can enable teachers in low-resourced schools to overcome systemic barriers and embed innovative ICT use into their pedagogy.

Keywords: Innovation, ICT, Teacher Professional Development (TPD), Low-Resourced Schools, Diffusion of Innovation (DOI), Diffusion of Innovation Plus (DOI-plus)

Introduction

The integration of Information and Communication Technologies (ICT) in education is increasingly recognised as a way to enhance teaching, foster innovation, and reduce systemic inequalities (Ranbir, 2024). In many countries, ICT has been positioned as a catalyst for improving curriculum delivery and expanding learning opportunities (Anastasopoulou et al., 2024). However, in low-resourced contexts, the potential of educational ICTs has not been fully realised due to limited coordinated efforts among stakeholders to harness their meaningful affordances (Sithole & Mbukanma, 2024). Schools in disadvantaged communities continue to face persistent infrastructural challenges such as limited access to ICT devices and unreliable connectivity, which in turn constrain the potential for innovative teaching practices (Padayachee, 2017; Dlamini, 2023). Furthermore, even when ICT resources are available, teachers often lack the necessary training to integrate them into pedagogy in meaningful and effective ways (Nyakito et al., 2021). Training initiatives, where they exist, often prioritise

Corresponding author Nokulunga Sithabile Ndlovu. E-mail: Nokulunga.ndlovu@wits.ac.za

ORCID

Matjema Caroline Maeane <https://orcid.org/0000-0002-1340-2581>

Nokulunga Sithabile Ndlovu <https://orcid.org/0000-0003-3368-2880>

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operational skills over pedagogical application, leaving teachers underprepared to innovatively transform their classroom practice (Graham et al., 2020; Mdodana-Zide, 2023).

The disconnect between resource availability and the effective use thereof reflects a broader challenge that is evident in the design of most ICT teacher professional development (ICT-TPD) interventions (Kabasiita et al., 2024). Studies from other contexts, such as those in middle to high-income communities, have shown that when PD is constant, context-sensitive, and linked to teachers' classroom realities, it can significantly increase teachers' willingness and capacity to adopt these ICTs for classroom innovation (Nyakito et al., 2021; Li et al., 2019; Murithi & Yoo, 2021). However, in South Africa's low-resourced schools, particularly primary schools, ICT-TPD programmes, if offered, often fail to adequately address the systemic barriers that teachers face, resulting in uneven and unsustainable integration (Mathebula et al., 2025; Hennessy et al., 2022). This raises a critical gap in understanding how ICT-TPD can be structured to not only build technical competence but also empower teachers to innovate within resource-constrained environments.

Based on this background, this study investigates how ICT-TPD can foster teacher innovation in a low-resourced South African primary school. The study aimed to explore how a structured ICT-TPD programme shaped teachers' use of ICT, to identify the barriers that limited their ability to sustain pedagogical innovation, and to determine what kinds of support could help them integrate ICT in ways that are relevant to their context. To achieve this, the study employed a mixed-methods case study design that combined surveys, rubric-based assessments of e-portfolios, semi-structured interviews, and field notes gathered from six teachers. The following research questions guided the study:

1. How do teachers in a low-resourced South African primary school engage with and integrate ICT into their pedagogical practice following participation in an ICT-TPD programme?
2. What barriers constrain teachers' ability to apply ICT-based pedagogical innovation consistently in low-resourced primary school contexts?
3. How can ICT-TPD be designed to enable teachers to integrate ICT skills pedagogically in ways that are both contextually relevant and supportive of sustained innovation?

This study contributes to the broader discourse on ICT in education by focusing on the voices and experiences of teachers in a low-resourced South African primary school. By examining the barriers that constrain pedagogical innovation along with the opportunities that can be unlocked through targeted PD, this research seeks to generate critical insights that are both contextually relevant and transferable to other low-income educational settings. In doing so, this study positions ICT-TPD not merely as an instrument for skill acquisition, but rather as a potential catalyst for pedagogical innovation that is responsive to the realities of resource-constrained environments. Nevertheless, because the findings reflect the experiences of a single school, they may not be generalisable to all low-resourced contexts. In addition, teachers' personal access to ICT devices outside the programme could not be fully determined, which may have influenced their level of experimentation. These limitations do not diminish the value of the findings but clarify the contextual boundaries within which they should be interpreted.

Literature review

The integration of ICT in education has been widely promoted as a mechanism for enhancing teaching, supporting innovation, and addressing educational inequalities (Tedla, 2012; Murithi & Yoo, 2021). However, the literature consistently highlights that implementation in low-resourced contexts is shaped by many challenges including systemic

constraints (Tedla, 2012; Murithi & Yoo, 2021). In South Africa, inequalities in ICT provision remain deeply entrenched, reflecting broader socio-economic disparities (Mdodana-Zide, 2023; Dlamini, 2023; Li et al., 2019; Tedla, 2012). Surveys of ICT use in schools reveal that while some progress has been made in increasing access, resource distribution remains uneven, with many schools lacking reliable infrastructure or connectivity (Mathebula, Moila, Maile & Mnisi, 2025; Padayachee, 2017). This infrastructural divide not only limits the use of ICT but also reinforces existing inequalities between the advantaged and the disadvantaged schools.

However, beyond access, the literature underscores the challenge of ensuring that ICT is used effectively for pedagogy. Graham, Stols & Kapp (2020) found that even where teachers had access to ICT resources, the integration into daily practice was inconsistent, often due to a lack of confidence or insufficient training in the skills required for integration. Training provided to teachers frequently emphasises operational skills, such as using software or devices, but does not adequately prepare teachers to integrate ICT into curriculum delivery in ways that enhance learning outcomes (Mdodana-Zide, 2023; Ofosu-Asare, 2024). This reflects a broader pattern across low- and middle-income countries, where teacher professional development often fails to connect technical skills with pedagogical innovation (Hennessy et al., 2022).

Comparative studies highlight the importance of professional development that is continuous, contextually relevant, and responsive to teachers' needs. For example, Li, Yamaguchi, Sukhbaatar, and Takada (2019) demonstrated that professional development in Mongolia significantly influenced teachers' readiness to integrate ICT when programmes were designed to be collaborative and sustained. Similarly, Murithi and Yoo (2021) observed that Kenyan teachers working within the competency-based curriculum reform faced difficulties in ICT integration largely due to gaps in professional development and systemic support. These studies align with Ofosu-Asare's (2024) argument that even in contexts where resources are scarce, innovative frameworks for teacher training can empower teachers to develop ICT-based pedagogical practices.

There is a need for ICT-TPD models that go beyond basic technical training and directly engage teachers in rethinking pedagogy through ICT. This can be facilitated by leadership and institutional systems that help sustain innovation (Nuriman, Niswanto, & Ismail, 2025). Effective teacher training must therefore be complemented by organisational strategies that support long-term integration.

Taken together, the literature shows that although ICT-TPD has the potential to foster teacher innovation, its effectiveness in low-resourced primary schools is limited by systemic inequalities, inadequate infrastructure, and training models that focus more on technical skills than on pedagogical application. Teachers' adoption of ICT is shaped not only by access and competence but also by the degree to which innovations align with their curriculum needs, classroom realities, and opportunities for experimentation. These factors underscore the need for professional development models that are responsive to context and directly linked to teachers' pedagogical challenges. These multi-layered constraints highlight the importance of analytical frameworks such as Diffusion of Innovation (DOI), which can systematically explain how teachers adopt, adapt, and sustain ICT integration in contexts shaped by structural inequalities.

Theoretical framework

This section draws on Rogers' (2003) Diffusion of Innovation (DOI) theory to analyse how ICT adoption occurs in low-resourced South African primary schools. The framework provides a structured lens for interpreting teacher engagement, identifying adoption challenges, and informing ICT-TPD design. This positioning is strengthened by the fact that DOI explains

how new practices spread within a social system, making it especially relevant in contexts shaped by persistent infrastructural constraints.

The DOI framework, in its attributes for innovation, emphasises that the uptake of innovations is shaped by five key qualities, namely relative advantage, compatibility, complexity, trialability, and observability (Sahin, 2006). These constructs are particularly relevant for analysing how teachers in low-resourced schools would engage with ICT, integrate it into curriculum delivery, and sustain pedagogical innovation within constrained contexts. In this study, the innovation under consideration is the integration of ICTs in education, facilitated through a targeted ICT-TPD programme designed for teachers in a low-resourced primary school.

Figure 1 presents a schematic representation of the Diffusion of Innovation framework, illustrating the five key attributes that influence ICT adoption in educational contexts.

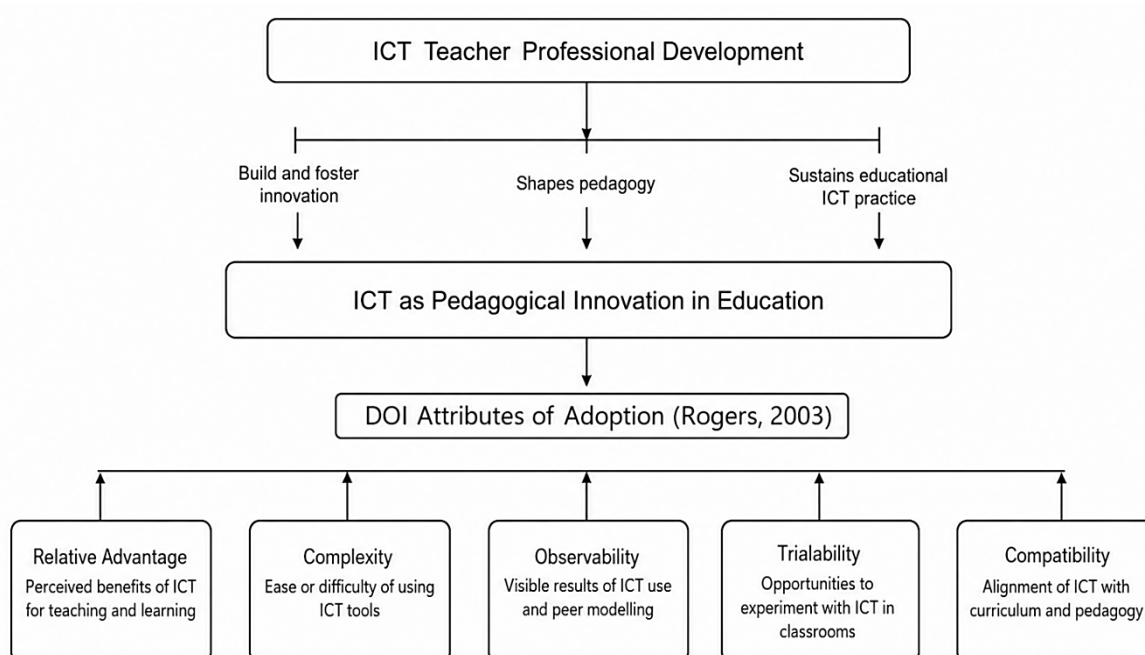


Figure 1 ICT Adoption in Education through TPD and DOI Attributes

Relative advantage refers to the extent to which an innovation is perceived as being more beneficial than existing practices (Sahin, 2006). For teachers in under-resourced schools, this perception is central to their potential adoption of ICT in their pedagogical practice. When ICT tools are seen to improve lesson delivery, learner engagement, or assessment practices, teachers are more inclined to integrate them despite infrastructural challenges (Mathebula et al., 2025). Conversely, if the perceived benefit is minimal or unclear, teachers are less likely to prioritise ICT in their teaching.

Compatibility highlights the degree to which the use of ICT aligns with teachers' pedagogical values, classroom routines, and curriculum demands (Sahin, 2006). In South Africa's diverse and often resource-limited classrooms, technologies that resonate with teachers' established practices are more likely to be adopted. ICT-TPD that explicitly connects digital tools to curriculum outcomes and classroom realities enhances this compatibility, reducing resistance to the innovation often compelled by discomfort - and fostering meaningful uptake (Mathebula et al., 2025).

Complexity concerns the perceived difficulty of using ICT effectively (Sahin, 2006). Teachers are less likely to persist with ICT integration if devices are unreliable, applications are unfamiliar, or training feels overly technical (Mathebula et al., 2025). Within an ICT-TPD, it is crucial to address the complexity of the innovation through scaffolded learning, peer mentoring, and accessible support structures, in order to build teachers' confidence and sustain learner engagement.

Trialability and *observability* focus the role of experimentation and visible outcomes in shaping the potential for adoption. Teachers need safe opportunities to experiment with ICT in their classrooms, reflect on outcomes, and refine their approaches (Mathebula et al., 2025). Equally, seeing colleagues successfully implement ICTs in their teaching practice provides social evidence to others and further reinforces adoption across the teaching community (Sahin, 2006). ICT-TPD programmes that prioritise classroom-based experimentation and peer modelling are therefore more likely to encourage sustained employment of the innovation.

Applying DOI to this research is particularly relevant given the persistent digital divide in South Africa's education sector. The framework helps analyse how individual teacher perceptions intersect with structural constraints such as limited connectivity, access to devices, and workload pressures. It also offers a prescriptive foundation for rethinking ICT-TPD design.

However, the five DOI attributes explain initial adoption more effectively than long-term sustainability. In low-resourced contexts, factors such as *unreliable electricity*, *insufficient device access*, and *limited institutional support* affect ongoing ICT use at a systemic level that DOI alone cannot fully capture. These contextual realities emerged strongly in the findings and indicate the need for an expanded framework.

For this reason, the study extends Rogers' model by incorporating *Contextual Sustainability* as a sixth attribute, forming what is referred to as *DOI-plus*. This added attribute captures the macro-level infrastructural and institutional conditions needed for sustained ICT integration, particularly in Global South contexts where resource inequalities shape innovation. The *DOI-plus* framework therefore strengthens the interpretation of findings and provides a contextually responsive lens for designing future ICT-TPD interventions.

Methodology

This study employed the mixed-methods research design, incorporating both quantitative and qualitative approaches. The quantitative component involved surveys and rubric-based assessments of e-portfolios, while the qualitative component included semi-structured interviews and field notes. The mixed-methods approach was chosen for its pragmatic ability to generate both measurable data and rich interpretive insights (Creswell & Creswell, 2018), which offered a comprehensive understanding of how ICT-TPD influenced teacher innovation in a low-resourced South African primary school.

Population and Sampling

The study was conducted in a low-resourced public primary school located in Johannesburg, Gauteng Province. The target population comprised the 30 teachers employed at the school. All 30 teachers were invited to complete the baseline survey, of whom 25 did so, however, only 12 teachers enrolled in the ICT-TPD programme. Of these, six teachers completed the entire programme and were therefore selected as the primary focus of the study. A purposive sampling technique was employed to ensure that participants had direct experience of the ICT-TPD intervention and could provide relevant insights into the opportunities and constraints of ICT integration (Creswell & Creswell, 2018; Silverman, 2013).

Data Collection Instruments

Data were collected using four complementary tools:

- Surveys: Pre- and post-intervention surveys measured changes in teachers' ICT competence, confidence, and innovation. The responses provided both quantifiable and interpretive measures of teachers' perceptions and practices.
- Semi-structured interviews: Conducted after the intervention, these interviews explored teachers' reflections on the ICT-TPD programme, the challenges encountered, and the perceived changes in their pedagogical practice.
- Field notes: These were recorded throughout the training sessions, capturing observational data on teachers' engagement, participation, and adaptation of ICT tools presented to them in the intervention.
- E-portfolios and rubric: Teachers developed e-portfolios as part of the ICT-TPD programme. These were assessed using a criterion-referenced rubric (Jonsson & Svingby, 2007), which evaluated their ICT competency skill and their ability to integrate ICT into teaching materials and lesson designs.

This combination of tools allowed triangulation across self-reported, observed, and assessed data sources, thus strengthening the study's validity.

Data Analysis

Quantitative survey data were analysed using descriptive statistics to identify trends, changes, and variations in teachers' ICT competence and innovation (Creswell & Creswell, 2018). Rubric scores from the e-portfolios were similarly summarised to assess the teachers' level of ICT competencies in being able to integrate the innovation into their teaching practice.

Qualitative data from interviews and field notes were analysed thematically (Creswell & Creswell, 2018; Silverman, 2013). Inductive coding, through the *in vivo* coding technique, was applied to identify emerging patterns in teachers' experiences, challenges, and innovative ICT practices. Triangulation of the quantitative and qualitative findings enabled a critical understanding of how teachers engaged with the ICT-TPD intervention and the contextual barriers they encountered.

Ethical Considerations

Ethical approval for the study was obtained from the University of the Witwatersrand Research Ethics Committee. Permission was also secured from the Gauteng Department of Education (GDE) and the investigated school principal. Participation was voluntary, with informed consent obtained from all participants. Anonymity and confidentiality were ensured by removing identifying information from transcripts and the survey responses. Teachers were informed that they could withdraw from the study at any stage without penalty. The collected data were securely stored and used solely for academic purposes.

Data presentation

This section presents the key findings from the ICT-TPD programme in the low-resourced South African primary school. Quantitative survey and rubric data are reported first to establish measurable trends, followed by qualitative insights that contextualise and explain these patterns. The results are organised according to the three research questions.

Description of the study participants

The target population for this study comprised all 30 teachers employed at a low-resourced primary school in Johannesburg. From this group, 25 teachers formed the accessible population, as they completed the baseline digital competency survey. Participation later

declined due to contextual and workload pressures, resulting in 12 teachers enrolling in the ICT-TPD programme. Of these, six teachers fully completed all training sessions and tasks, forming the final sample and analytic group for this study. Ages within this group ranged from 25 to 60 years, representing early, mid, and late career stages. Gender representation was balanced, with three males and three females, and five participants identified as Black African and one as Indian. Two members of this analytic sample entered the programme with comparatively stronger technological experience and actively supported less experienced colleagues by demonstrating tools and sharing practical strategies during and after sessions. Although economic backgrounds were not disclosed, the accessible sample still provided a rich basis for examining teachers' digital competencies, their attitudes towards ICT integration, and the extent to which the ICT-TPD fostered innovative curriculum practices.

Teacher Engagement and Integration of ICT into Pedagogy

At baseline, 25 teachers completed the digital competency survey. Responses revealed uneven familiarity with ICT tools. *Table 1* summarises their self-assessed competence in using Microsoft Word, PowerPoint, Excel, and online tools for teaching and assessment.

Table 1 Survey Descriptive Statistics

Survey Indicators		No.	Minimum	Maximum	Mean	Std. Deviation
Tool Utilisation in Teaching:	Microsoft Word to create Content	25	0	4	2.44	1.45
	Microsoft Word for lesson prep and assessment	25	0	4	2.92	1.35
	Microsoft PowerPoint to create Content	25	0	4	2.52	1.48
	Microsoft PowerPoint to present lessons	25	0	4	2.44	1.39
	Microsoft Excel to record, calculate and evaluate assessment.	25	0	4	2.64	1.50
	Any online tool to teach or assess learners.	25	0	4	2.48	1.45
Valid N (listwise)		25				

The baseline data from 25 teachers show that ICT use was uneven. Self-ratings on a 0–4 scale indicate that competence was strongest in the use of Microsoft Word for lesson preparation and assessment ($M = 2.92$, $SD = 1.35$) and Microsoft Excel for assessment management ($M = 2.64$, $SD = 1.50$). Competence was weaker for PowerPoint presentation ($M = 2.44$, $SD = 1.39$), Word for content creation ($M = 2.44$, $SD = 1.45$), and online tools for teaching or assessment ($M = 2.48$, $SD = 1.45$). All tools show wide variability ($SD \approx 1.35$ – 1.50), meaning that while some teachers reported confidence, others rated themselves at beginner level.

The implication for this is that at baseline, teachers primarily used ICT for administrative purposes rather than for direct, learner-facing pedagogy. The variation across staff underscores the need for differentiated support in ICT-TPD such as foundational training for novices and more advanced pedagogical modelling for experienced users. For instance, one of the participants (T1) reflected – when interviewed – on her limited skills before the programme, explaining: “*I could type my assessments... just typing and saving and all that.*” This echoes the baseline survey trend where Word was used primarily for basic administrative functions, with little evidence of pedagogical application. *Figure 2* provides context to this response:

Okay. Actually, I'll start from, uh, Wits when I started doing my undergrad. I, I didn't know I, what is the computer? I couldn't type, I used use one finger, but at some point I learned. I learned. Then, yeah, I was not that perfect, but I could type my assessments. Just the, the simple things.. Just typing and or not beyond that. Just typing and saving and all that. Yeah.

Figure 2 Teacher reflection on limited baseline ICT use, illustrating reliance on Microsoft Word primarily for administrative tasks

Although 25 teachers completed the baseline survey, only 12 enrolled in the ICT-TPD programme and 6 completed all training sessions and submitted e-portfolios. These 6 participants therefore constitute the analytic cohort for the post-training rubric assessment presented in Table 2. This narrowing from baseline to completion reflects both attrition and contextual constraints, such as workload and resource limitations.

Post-ICT-TPD Changes in Digital Competence and ICT Integration

Following the ICT-TPD programme, teachers demonstrated measurable improvements in their ICT competence and pedagogical integration. At baseline ($n = 25$), competence was uneven: teachers rated themselves higher in administrative tasks such as Word for lesson preparation ($M = 2.92$, $SD = 1.35$) and Excel for assessment management ($M = 2.64$, $SD = 1.50$), but lower in classroom-facing applications such as PowerPoint presentation ($M = 2.44$, $SD = 1.39$) and online tools ($M = 2.48$, $SD = 1.45$). These results highlighted that while some teachers were already confident, others remained at beginner level.

Of the original cohort, only 12 teachers enrolled in the ICT-TPD and 6 completed all sessions and e-portfolios. Among these completers, notable improvements were visible. Qualitative reflections highlighted growth across the spectrum of competence:

- T5 admitted pre-training that “*we had never used this tool in our teaching*” but later explained that “*creating a Google Form was time-efficient and easy to share with my colleagues.*”
- T4 acknowledged, “*I have never used ICT for teaching before*” yet described experimenting with interactive worksheets post-training.
- T6, who entered with prior exposure, also reported enhanced creativity with tools like Canva and collaborative resources.
- Post-PD survey responses confirmed this trend. T4 responded: “*The diversity and informative nature of ICT tools simplified and advanced conveying content knowledge in and outside of classroom spaces.*” T4 further added that, “*Creating online learning materials such as worksheets for learners*” was the most engaging aspect of the training, and similarly, T1, T2 and T6 highlighted “*interactive worksheets*” and “*PowerPoint presentation making*” as particularly most relevant.

These qualitative accounts align with the post-training rubric results in Table 2, which show notable progress in several domains.

Table 2 Post-training Scores – Criterion-Referenced Rubric (CRR) Statistics

	Participant	Technology-Use	Communication and Collaboration	Pedagogical Practice	Management-Use
N	Valid	6	6	6	6
	Missing	0	0	0	0
Mean		2.67	2.33	2.33	1.50
Median		3.00	2.50	2.00	1.00
Mode		3	3	2	1
Std. Deviation		0.816	0.816	0.516	0.837
Variance		0.667	0.667	0.267	0.700
Skewness		-2.449	-0.857	0.968	1.537
Std. Error of Skewness		0.845	0.845	0.845	0.845
Range		2	2	1	2

The quantitative results in Table 2 indicate notable gains in Technology Use, with most teachers confidently applying digital tools after the ICT-TPD. Improvements were also seen in Communication and Pedagogical Practice, although not all participants moved beyond intermediate levels. Management Use – which refers to teachers’ application of ICT for administrative and classroom management purposes, such as recording learner performance, organising materials, or streamlining communication with learners and parents – remained the weakest area. This reflects systemic and contextual barriers.

Barriers to Sustained ICT-Based Pedagogical Innovation

This theme addresses RQ2 by highlighting constraints that limited consistent ICT use. The quantitative results (Tables 1 and 2) revealed uneven competence and weak Management Use, while the qualitative data provided insights into the reasons behind these patterns. Three main barriers emerged: workload and time pressures, limited resources, and course delivery challenges, compounded by broader systemic and pedagogical constraints.

Workload and Time Constraints

Teachers struggled to balance professional duties with ICT training. T5 noted, “*sometimes we don’t get... enough time,*” while T4 emphasised that weekends were reserved for personal errands. T3 and T2 suggested scheduling training during holidays or spreading sessions over two days a week to alleviate time pressures. These reflections resonate with post-PD survey responses such as, “*the training could be done during holidays... teachers will not be overwhelmed with work.*” Such feedback clarifies why rubric scores for Management Use remained low; while teachers were engaged, their capacity to integrate ICT into administrative and classroom processes was constrained by time.

Resource Challenges

Access to devices, internet, and stable electricity remained significant obstacles. T1 explained that load-shedding required him to “*think proactively to ensure students still accessed the work,*” while others borrowed laptops or coped with intermittent Wi-Fi. Post-survey comments reinforced this, with T3 recommending an “*analysis of a school... to determine the availability of ICT resources.*” These insights show that despite gains in

Technology Use (Table 2), resource inequities constrained both Communication and Collaboration outcomes, as not all teachers had equal opportunity to apply their new skills.

Course Delivery Limitations

The pace and density of sessions posed difficulties for some. T3 felt that content was delivered too quickly, while another participant advised, *“taking one step at a time, not doing a lot of information at once.”* Such perspectives explain the uneven progression in Communication and Pedagogical Practice scores. Although rubric means were above intermediate levels, the qualitative feedback highlights that a slower, scaffolded approach may have enabled greater consistency across the group.

Together, these qualitative insights explain the quantitative pattern: strong progress in Technology Use, partial gains in Communication and Pedagogy, and persistent weakness in Management Use. This indicates that sustained innovation requires not only teacher motivation but also structural support, realistic pacing, and reliable resources.

Designing ICT-TPD to Support Pedagogically Relevant and Sustained Innovation

This theme addresses RQ3 and draws on both post-PD interviews and survey data, supported by the rubric results in Table 2.

Effective Course Design and Facilitation

Teachers stressed the importance of structured guidance and supportive facilitation. The post-survey confirmed this, with most participants reporting that facilitator demonstrations were *“always clear and easy to follow”* and that the approach made them feel engaged. These perceptions align with rubric improvements in Communication and Collaboration ($M = 2.33$), where half of the teachers demonstrated innovation. Facilitators' mentoring and the use of Professional Learning Communities (PLCs) strengthened teacher confidence and provided a space to practise skills in context.

Relevance of ICT Resources

Quantitative survey results showed that 100% of participants valued practical, free tools such as Google Forms and Canva, which were immediately transferable to classrooms. Teachers described these as the most relevant resources, consistent with rubric gains in Pedagogical Practice ($M = 2.33$). For instance, participants emphasised that interactive worksheets and PowerPoint presentations could be directly applied to lesson delivery.

Sustainment and Continuous Support

Survey feedback also highlighted sustainment needs: 83% requested follow-up workshops and 67% suggested scheduling during holidays to ease workload pressures. This helps explain why Management Use ($M = 1.50$) remained the weakest area in the rubric. Without structural adjustments such as flexible timing and ongoing support, teachers found it difficult to embed ICT into administrative and organisational aspects of their work. Both quantitative outcomes and qualitative reflections converge on the point that ICT-TPD is most effective when training is contextualised, paced appropriately, and supported by practical resources and mentoring. However, long-term innovation requires not just initial competence gains but also systemic conditions that allow teachers to sustain and deepen integration.

Post-Training Survey Insights

Post-survey responses reinforced these themes and justified the quantitative rubric findings (Table 2). Teachers consistently rated the training as engaging and supportive,

reporting that facilitator guidance and hands-on tasks improved their confidence. For example, T4 described the training as “*diverse and informative in advancing content delivery inside and outside the classroom,*” and highlighted interactive worksheets and PowerPoint as the most relevant components.

At the same time, survey feedback echoed barriers noted in the rubric: suggestions included slower pacing, stepwise demonstrations, additional practice tasks, and delivery during school holidays to ease workload pressures. These qualitative justifications explain why some domains, particularly Management Use, remained weaker despite overall gains.

Integration: Together, the rubric scores and post-survey feedback confirm that the ICT-TPD moved teachers beyond administrative ICT use toward more creative and contextually relevant pedagogy, while also revealing the structural and design factors required for sustained innovation.

Discussion

This study explored how teachers in a low-resourced South African primary school engaged with and integrated ICT-based pedagogical innovations following participation in an ICT Teacher Professional Development (ICT-TPD) programme. Engagement and integration were assessed against teachers’ ICT proficiency before and after the intervention, with both survey and rubric results complemented by qualitative accounts. This discussion interprets the findings in relation to existing literature and Rogers’ (2003) Diffusion of Innovation (DOI) framework, highlighting points of convergence, divergence, and extension. The discussion is structured around the three research questions.

RQ1. Teacher Engagement and Integration of ICT in Pedagogical Practice

Findings suggest that ICT-TPD can significantly improve teachers’ engagement with digital tools and their integration into teaching practice. Baseline survey data (n = 25) showed uneven competence, with stronger use of Word and Excel for administrative tasks and weaker application of PowerPoint and online tools in pedagogy. Post-training rubric results (n = 6) confirmed measurable gains in Technology Use and Pedagogical Practice, supported by qualitative evidence of teachers experimenting with Google Forms, Canva, and interactive worksheets.

These results align with Li et al. (2019) and Hennessy et al. (2022), who found that context-sensitive professional development enhances teachers’ confidence and willingness to experiment with ICT. They also echo Vandeyar (2013), who emphasised communities of practice as enablers of ICT adoption through peer support. The clear improvement from baseline to post-training suggests that visible outcomes and opportunities for trialability are critical drivers of ICT uptake. This reflects improvements in DOI attributes such as Relative Advantage, Trialability, Compatibility, and Observability, which collectively shaped teachers’ willingness to adopt ICT tools.

However, this study diverges from earlier work by Dlamini and Mbatha (2018) and Padayachee (2017), which documented persistent disengagement due to limited relevance and weak institutional support. The difference lies in tailoring: unlike generic programmes, the ICT-TPD in this study provided directly applicable tools and peer modelling, making innovation observable and practically relevant. In DOI terms, Relative Advantage and Observability were key motivators for engagement.

RQ2. Barriers to Consistent ICT Integration

Despite these gains, sustained ICT integration was constrained by workload, resource scarcity, unreliable electricity, and the pace of training. Quantitative evidence confirmed weaker outcomes in Management Use, while qualitative accounts clarified why teachers struggled to embed ICT in routine administration due to contextual pressures. These findings mirror barriers reported by Mathebula et al. (2025) and Mdodana-Zide (2023), who show how systemic inequalities undermine consistent adoption.

While Graham et al. (2020) suggest teacher motivation alone can sustain ICT use, this study demonstrates that motivation without institutional and infrastructural support cannot overcome entrenched constraints. Complexity (ease of use) and Compatibility (fit with curriculum goals) within DOI were clearly relevant, but systemic issues extended beyond these categories, limiting sustainability even when teachers were motivated and skilled. These systemic constraints highlight the limitations of DOI's five attributes, which explain initial adoption but do not fully account for sustainability in low-resourced schools.

RQ3. Designing ICT-TPD for Contextually Relevant and Sustainable Innovation

The study highlights the need for PD that is flexible, scaffolded, and directly relevant to teachers' classroom realities. Post-survey responses confirmed strong appreciation for practical, free tools (e.g., Google Forms, Canva) and supportive facilitation, but also emphasised the need for slower pacing, additional practice, and training during holidays to ease workload. These findings reinforce Li et al. (2019) and Hennessy et al. (2022), who emphasise structured, responsive design, and Vandeyar (2014), who stresses the role of localised support systems.

This study crucially extends the literature by showing that sustainment requires proactive contingency planning, such as preparing for load-shedding and ensuring device access. These are not captured by DOI's five attributes but are central in low-resourced contexts. This gap motivates the introduction of the Contextual Sustainability dimension in the DOI-plus extension.

Theoretical Contribution: Toward DOI-Plus

The findings affirm DOI's relevance in explaining initial ICT adoption, particularly through Relative Advantage, Trialability, Observability, Complexity, and Compatibility. Yet, they also reveal its limitations in capturing long-term ICT usage in resource-constrained environments. The identified weaknesses in Management Use and persistent barriers point to existing structural legacies – unreliable infrastructure, socio-economic inequalities, and institutional gaps – that fall outside DOI's original scope. These findings justify the need to extend DOI to account for systemic and infrastructural conditions influencing ICT adoption.

To address this, the study proposes a sixth attribute: *Contextual Sustainability*. This attribute recognises that systemic and infrastructural conditions fundamentally shape whether ICT integration can be viable in the long-term. By foregrounding systemic issues such as unreliable electricity supply due to persistent power cuts, limited access to affordable and functional devices due to poor budgets, and rigid institutional scheduling to heavy professional workloads and overcrowded classrooms in under-resourced schools, this study adapts DOI into a DOI-plus framework, better suited to Global South contexts. *Figure 3* below, illustrates the suggested DOI-plus framework.

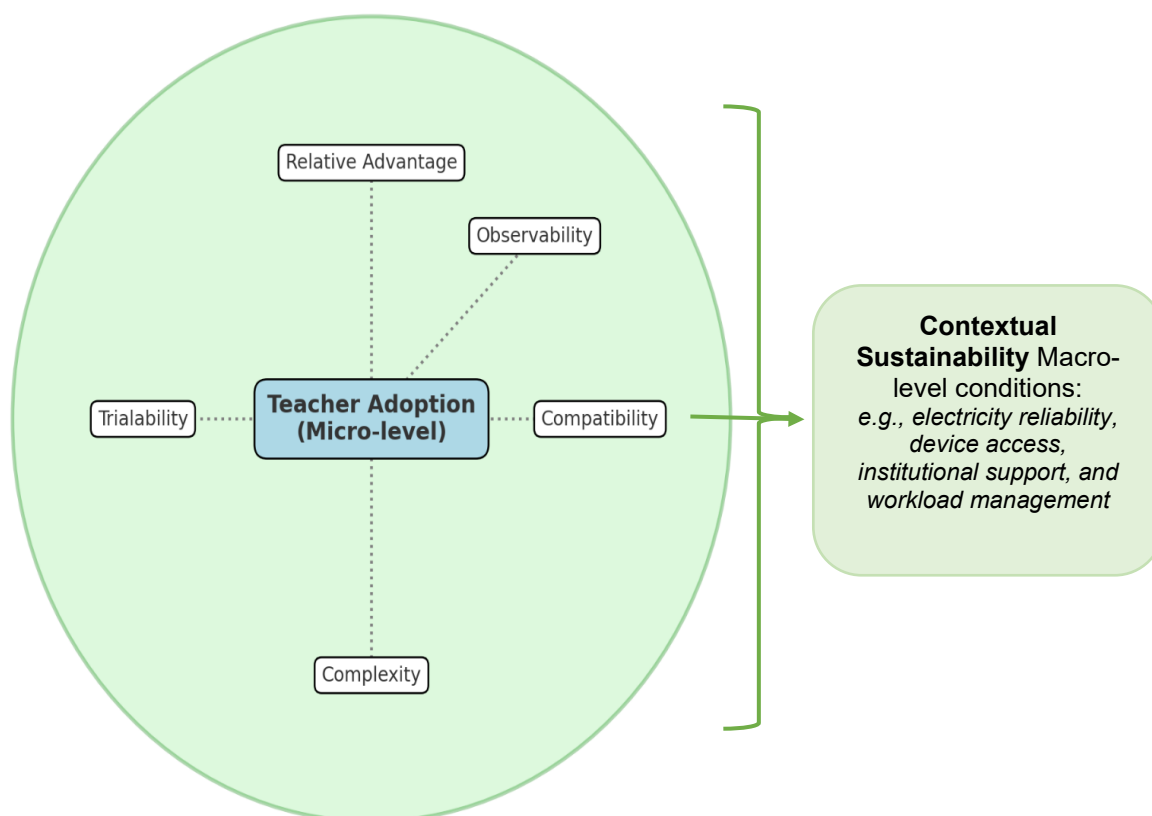


Figure 3 DOI-plus framework

The above framework extends Rogers' (2003) model by adding *Contextual Sustainability* as a sixth attribute, highlighting systemic and environmental conditions needed for sustained ICT adoption. This extension contributes theoretically by contextualising DOI for unique contexts, particularly low-resource settings, and practically by guiding the design of ICT-TPD and policy interventions that address not just individual adoption but also the systemic conditions necessary for sustainability.

Recommendations

The findings show that ICT adoption among teachers was strongest when training emphasised practical benefits, relevance to curriculum demands, and opportunities for experimentation. To strengthen and sustain these outcomes, ICT-TPD programmes should emphasise tools that demonstrate clear advantages for teaching and learning, while ensuring compatibility with existing curriculum requirements and classroom realities. This is particularly important given the baseline survey results, where ICT was mainly used for administrative purposes such as Word and Excel.

Training must also reduce the perceived complexity of ICT integration. The post-survey responses revealed that pacing and information overload hindered confidence, with teachers suggesting stepwise instruction and more manageable workloads. Scaffolding content into smaller, hands-on modules and offering peer support through PLCs can directly address these concerns while reinforcing trialability. Teachers' reflections showed that experimentation with

tools such as interactive worksheets and Google Forms increased engagement, demonstrating the value of providing structured opportunities to test and adapt new resources.

Long-term diffusion requires observability and sustainability. Teachers should be encouraged to share successful ICT practices in staff meetings and PLCs, reinforcing collective learning and motivation. However, systemic constraints such as unreliable electricity, limited access to devices, and workload pressures remain the most significant barriers. Here, the proposed DOI-Plus attribute of *Contextual Sustainability* becomes critical. Professional development must anticipate these barriers by embedding contingency planning (e.g., offline-ready resources), pursuing partnerships to improve device access, and scheduling training during periods when teachers are less burdened by administrative tasks.

In essence, ICT-TPD in low-resourced schools must be designed as a continuous and context-sensitive process. By grounding recommendations in the DOI-Plus framework, the study emphasises that sustainable ICT integration depends not only on individual teacher motivation but also on the alignment of innovations with curriculum, institutional structures, and the systemic realities of the Global South. These recommendations underscore the importance of integrating DOI-Plus principles into PD design, ensuring that individual competencies and systemic enablers are addressed in tandem.

Conclusion

This study examined how an ICT-Teacher Professional Development (ICT-TPD) programme influenced teacher engagement, integration, and innovation in a low-resourced South African primary school. Findings show that while teachers displayed enthusiasm and progressed from administrative to more creative ICT use, sustained innovation was constrained by workload, time pressures, unreliable infrastructure, and varied digital competencies. These systemic barriers limited consistent adoption despite evident gains in confidence and pedagogical experimentation. The study found that teachers' engagement with ICT improved significantly when digital tools aligned closely with curriculum tasks and provided opportunities for experimentation.

The results underscore that effective ICT-TPD must go beyond once-off technical training. Sustainable integration requires scaffolded learning, alignment with curriculum demands, and opportunities for collaboration through professional learning communities. Ongoing mentoring, differentiated support, and resource provision are equally critical to address structural barriers that hinder long-term ICT adoption.

Policy and practice should therefore prioritise continuous and context-sensitive ICT-TPD. By incorporating frameworks such as Rogers' Diffusion of Innovation and extending it through the DOI-Plus attribute of *Contextual Sustainability*, interventions can better account for the realities of the Global South. The DOI-plus framework introduced in this study provides a more contextually responsive explanation of ICT adoption by highlighting that sustainable innovation requires systemic and infrastructural support alongside teacher competence. This study demonstrates that lasting pedagogical innovation emerges when professional development simultaneously supports teacher motivation and addresses systemic inequities, equipping both educators and learners in under-resourced contexts for meaningful participation in the digital age. Future research and policy should therefore pursue integrated strategies that develop teacher capacity while concurrently mitigating structural barriers, ensuring that ICT-TPD becomes a catalyst for sustainable pedagogical transformation.

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