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Positive Attitudes, Constrained Practice: School-Level Support and Chemistry Teachers' ICT Integration in Mkuranga District, Tanzania

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Abstract : Digital education reforms in Tanzania are expanding, yet secondary schools face gaps in infrastructure, training, connectivity, and technical support. This study examined whether school-level support and infrastructure shaped chemistry teachers' attitudes toward information and communication technology (ICT) integration in Mkuranga District. The objective was to determine how training and infrastructure influenced those attitudes. A mixed-method case-study design was used. The study involved 56 participants: 46 chemistry teachers and 10 heads of schools; 10 teachers and all heads joined interviews, and 10 lessons were observed. Structured questionnaires, semi-structured interviews, and a non-participant observation checklist generated data. Following permission and consent, questionnaires were administered, 30–45-minute interviews were audio-recorded, and observations were documented. Frequencies, percentages, and simple linear regression at $\alpha = .05$ analysed quantitative data; thematic analysis and triangulation integrated qualitative and observational evidence. Literature-based item development, expert review, pilot testing, construct alignment, and triangulation supported validity. Test–retest reliability of at least .80 and Cronbach's alpha of at least .70 were prespecified, although realised coefficients were not reported. Participation was voluntary, confidential, anonymous, and withdrawable. Reliable electricity (80.1%) and supportive leadership (76.2%) coexisted with inadequate resources (85.0%), limited regular training (35.7%), inadequate infrastructure (35.7%), and weak technical support (38.1%). Support did not significantly predict attitudes, $R^2 = .009$, $F(1, 41) = 0.362$, $p = .551$. Teachers valued ICT but could not enact that commitment. The study concludes that attitude is not the principal bottleneck. It recommends targeted chemistry-focused professional development, equitable equipment and connectivity, and funded technical maintenance.

Keyword : chemistry education, ICT integration, school-level support, teacher attitudes, TPACK, Tanzania

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INTRODUCTION

Digital technology can make abstract chemical processes visible through simulations, animations, virtual laboratories, multimedia demonstrations, and access to scientific resources. Its educational value, however, depends on how well technology is aligned with subject matter, pedagogy, and learners' needs rather than on hardware provision alone. The 2023 Global Education Monitoring Report cautions that technology does not improve education automatically and identifies access, governance, teacher preparation, and appropriate content as necessary system conditions (UNESCO, 2023). Similarly, a recent systematic review of secondary education found that meaningful ICT integration is shaped by the interaction of resources, professional development, pedagogical knowledge, leadership, technical assistance, and curriculum alignment (Msafiri et al., 2023). These conclusions make teachers' attitudes important, but they also challenge any assumption that positive attitudes will translate directly into routine classroom use.

Across Africa, digital education policy increasingly treats teacher capability and infrastructure as interdependent. The African Union's Digital Education Strategy and Implementation Plan 2023–2028 prioritises connectivity and equipment alongside curriculum-aligned content and teacher digital-competency development (African Union Commission, 2022). Contemporary studies nevertheless show a persistent implementation gap. Rural South African science teachers displayed stronger conventional content and pedagogical knowledge than technology-related TPACK domains (Shambare & Jita, 2024), while Rwandan chemistry teachers valued computer-based laboratory simulations but reported limited computers and insufficient professional training (Batamuliza et al., 2024). Evidence from Zimbabwe likewise indicates that positive attitudes and moderate competence can coexist with infrastructure and support constraints (Mbona et al., 2026). The regional problem is therefore not a simple deficit of teacher willingness; it is the difficulty of converting willingness into pedagogically meaningful use under unequal institutional conditions.

Tanzania is now strengthening digital teacher development: in 2025, UNESCO and the Tanzania Institute of Education began developing 15 ICT training modules for secondary teachers, aligned with national curricula and continuous professional development systems (UNESCO, 2025). Yet Tanzanian evidence remains locally uneven. In Zanzibar, science teachers' actual integration practices were inefficient despite some positive beliefs, largely because of limited skills, knowledge, and confidence (Hamoud & Nzilano, 2024). In Kibaha District, Pwani Region, science and mathematics teachers reported predominantly negative beliefs that corresponded with limited ICT use (Rimba & Tarmo, 2025). Neither study isolates chemistry teachers in Mkuranga District or triangulates a statistical test of school support–attitude relationships with interviews and observed lessons. Addressing this gap, the present study examined the role of school-level support—especially training and infrastructure—in shaping chemistry teachers' attitudes toward ICT integration in Mkuranga's public secondary schools. Its contribution is to distinguish teachers' endorsement of ICT from the institutional capacity to enact that endorsement.

Literature Review

1. Theoretical Review

The study was guided by the Technological Pedagogical Content Knowledge (TPACK) framework. TPACK proposes that effective technology-supported teaching depends on the dynamic integration of technological knowledge, pedagogical knowledge, and content knowledge, including the intersections among these domains (Mishra & Koehler, 2006). This is especially relevant to chemistry, where knowing how to operate a projector or computer is not equivalent to knowing when a molecular animation, simulation, video experiment, or virtual laboratory will improve conceptual understanding. A chemistry teacher must select a tool, represent disciplinary content accurately, and organise instruction so that learners actively interpret the representation. TPACK therefore moves analysis beyond generic digital skill to the pedagogical use of technology for specific chemistry concepts.

The framework's contextual dimension is central to this article. Mishra (2019) recast the outer context of TPACK as contextual knowledge (XK): teachers' knowledge of the organisational, policy, infrastructural, cultural, and resource conditions within which technology use occurs. This extension helps explain why competent, motivated teachers may not integrate ICT when electricity, devices, connectivity, technical support, time, or leadership arrangements are inadequate. It also prevents an overly individualised account of implementation failure. TPACK has limitations—its knowledge domains can overlap empirically, self-reported competence may not match enacted practice, and the framework does not by itself specify causal mechanisms—but XK provides a defensible basis for examining school-level support in a resource-constrained setting.

The analytical implication is that attitude, competence, and enactment should not be treated as interchangeable. TPACK may influence teachers' confidence and intention, while contextual conditions shape whether intention becomes practice. In a study of 314 in-service teachers, Bai et al. (2024) found that technology self-efficacy and attitude mediated the relationship between TPACK and behavioural intention. That model supports a psychological pathway to intended use, but it does not imply that institutional resources must strongly predict attitude in every setting. The present study therefore tested whether school support and infrastructure predicted attitude while using interviews and observations to examine a second possibility: support may matter more for implementation than for teachers' stated valuation of ICT.

Empirical Review

At the broadest level, recent evidence presents ICT integration as a multilevel process. Msafiri et al. (2023) synthesised secondary-education studies and identified inadequate resources, training, time, support, curriculum alignment, and pedagogical change as recurring barriers. Their review also described school leadership and culture as potential enablers when they combine a shared vision with resources, technical help, recognition, and monitoring. More recently, Mbona et al. (2026) surveyed 59 teachers in Zimbabwe and found positive attitudes and moderate competence alongside insufficient infrastructure and institutional support. Together, these studies suggest that favourable dispositions can be genuine but practically weak when school systems do not reduce the costs and risks of technology use.

Subject-specific African research sharpens this argument. Moosa and Ramnarain (2023) found that an empowerment-evaluation professional-development programme improved South African physical-science teachers' attitudes, beliefs, and intentions to integrate ICT, demonstrating that sustained, practice-centred development can influence psychological readiness. Shambare and Jita (2024), however, found technology-related TPACK deficiencies among 186 rural South African life-science teachers despite stronger conventional knowledge domains. In Rwanda, eight lower-secondary chemistry teachers perceived interactive computer-based laboratory simulations as useful for safety, collaboration, and practical learning, but limited computer access and insufficient professional training impeded adoption (Batamuliza et al., 2024). These results converge on the need for subject-specific professional learning rather than one-off generic computer training.

Tanzanian studies reveal variation that warrants closer local analysis. Hamoud and Nzilano (2024) used questionnaires, interviews, and observations with 60 Zanzibar science teachers and reported mixed beliefs and inefficient classroom integration, with inadequate skill, knowledge, and confidence as central constraints. Rimba and Tarmo (2025), studying 172 science and mathematics teachers in Kibaha District, found predominantly negative beliefs and a strong relationship between beliefs and reported adoption. These results differ from studies elsewhere in Africa that find positive attitudes despite constrained practice, suggesting that subject, location, exposure, school conditions, and measurement may alter the attitude–practice relationship. No identified study had tested school support as a predictor of chemistry teachers' attitudes in Mkuranga while also observing lessons and interviewing teachers and heads. This study addresses that empirical and geographical gap.

METHODOLOGY

The study adopted a mixed-methods approach because numerical patterns alone could not explain why chemistry teachers held particular attitudes or how school conditions affected their classroom decisions. Quantitative and qualitative evidence was integrated during interpretation. A case-study design bounded the inquiry to public secondary schools in Mkuranga District, Pwani Region, allowing the school context to be examined alongside individual teacher responses (Creswell & Plano Clark, 2018; Yin, 2018).

The target population comprised 62 chemistry teachers. The realised sample contained 56 unique participants: 46 chemistry teachers and 10 heads of schools from 10 public secondary schools. Schools were stratified by urban and rural location and then randomly selected; chemistry teachers were randomly selected within participating schools. For the qualitative strand, 10 chemistry teachers from the survey group and the 10 heads of schools were purposively interviewed. Ten chemistry lessons were selected for non-participant classroom observation. This structure enabled breadth through the teacher survey and contextual depth through interviews with classroom and school-level actors.

Three instruments were used. A structured questionnaire contained closed-ended and five-point Likert items measuring school support, infrastructure, and overall attitudes. A semi-structured interview schedule explored access to ICT, training, leadership, maintenance, connectivity, and teachers' experiences of technology-supported chemistry instruction. A structured observation checklist recorded available tools, the extent of classroom integration, teacher confidence, learner interaction, and technical or infrastructural constraints. Permission was obtained from St. Augustine University of Tanzania and the Mkuranga District Education Office. After written informed consent, questionnaires were administered to the 46 teachers, interviews lasting approximately 30–45 minutes were audio-recorded, and 10 lessons were observed without intervention. Data collection was scheduled to minimise disruption to teaching.

Questionnaire responses were coded and analysed using frequencies and percentages. Composite Likert scores were used in a simple linear regression testing whether school-level support and infrastructure predicted teachers' attitudes at an alpha level of .05. The reported regression degrees of freedom indicate 43 complete cases for this analysis. Interview recordings were transcribed and analysed thematically; observation notes were compared with questionnaire and interview patterns. Integration occurred through methodological triangulation, with convergence and divergence used to refine interpretation rather than forcing all sources into a single conclusion.

Content validity was addressed through literature-based item development and expert review; construct validity through alignment between items, the study objectives, and TPACK; and face validity through pilot testing (Cohen et al., 2018). The protocol prespecified test–retest reliability of at least .80 and Cronbach's alpha of at least .70, consistent with conventional internal-consistency guidance (Tavakol & Dennick, 2011). Cross-checking of interview coding and triangulation across three instruments were intended to strengthen dependability and credibility. The dissertation, however, did not report the realised test–retest coefficient, Cronbach's alpha, or inter-rater agreement; this omission limits psychometric appraisal and should be remedied in the submission record. Ethical safeguards included institutional permission, written informed consent, voluntary participation, the right to withdraw without penalty, anonymisation of participants, confidentiality, restricted data access, respect for participants, and efforts to minimise harm.

FINDINGS AND DISCUSSION

The central finding was a clear attitude–implementation gap: chemistry teachers reported substantial shortcomings in school support and infrastructure, but these conditions did not significantly predict their attitudes toward ICT integration. In practical terms, the teachers' appreciation of ICT remained high even when the institutional conditions for routine use were weak. This distinction matters because a non-significant support–attitude coefficient is not evidence that equipment, training, connectivity, and maintenance are unimportant. Instead, the combined data indicate that these factors constrained what teachers could do more than what they believed.

Table 1 condenses the most consequential descriptive evidence. Reliable electricity and leadership encouragement were relatively common, reported by 80.1% and 76.2% of teachers, respectively. Basic ICT facilities were reported by 66.7%. These enabling conditions were counterbalanced by much weaker professional and technical systems: only 35.7% reported regular ICT training, 35.7% considered infrastructure adequate, and 38.1%

reported available technical support. The strongest barrier signal was that 85.0% agreed that inadequate ICT resources limited integration. The pattern shows why counting the presence of computers or electricity can overstate readiness. Availability did not necessarily mean sufficient devices, stable internet, classroom access, functional equipment, suitable chemistry software, or timely repair.

Table 1.
Reported school-level conditions for ICT integration (n = 46)

School-level condition	Agree or strongly agree
ICT facilities are available	66.7%
Electricity is reliable	80.1%
Regular ICT training is provided	35.7%
ICT infrastructure is adequate	35.7%
School leadership supports ICT integration	76.2%
Inadequate ICT resources limit integration	85.0%
Technical support is available	38.1%

The regression evidence reinforces the distinction between attitudes and implementation. School support and infrastructure had only a very weak positive association with attitude, $R = .095$, and explained 0.9% of its variance, $R^2 = .009$ (adjusted $R^2 = -.015$). The model was not statistically significant, $F(1, 41) = 0.362$, $p = .551$. The unstandardised coefficient was positive but imprecise, $B = 0.125$, $SE = 0.207$, $t = 0.602$, $p = .551$. The appropriate conclusion is that the study did not find evidence that the measured support composite predicted attitudes in this sample; it is not that support has no educational effect. The model used 43 complete cases, inferred from total degrees of freedom of 42, which further reduced statistical power.

Qualitative and observational evidence explained the statistical result. Teachers repeatedly separated their willingness to use ICT from their opportunity to do so. Computers and projectors existed in some schools but were shared across classes; internet connections could fail during lessons; broken equipment sometimes remained unusable because technicians were unavailable; and refresher training was irregular. One teacher explained that when equipment failed, "there is nobody to repair it in time" (Participant P10). Another stressed that technologies change rapidly while "opportunities for our refresher courses are limited" (Participant P8). Observations confirmed variation across schools: some lessons had a working laptop, projector, electricity, and cables, whereas other classrooms had insufficient or damaged equipment and no specialist technical assistance. Thus, positive attitudes were sustained by perceived pedagogical usefulness, while implementation depended on access at the time and place of teaching.

This result is consistent with evidence that positive disposition can coexist with constrained practice. Mbona et al. (2026) similarly found positive attitudes and moderate ICT competence among Zimbabwean teachers despite infrastructure and support barriers. Hamoud and Nzilano (2024) reported inefficient ICT practice in Zanzibar even where some science teachers held positive beliefs, and Batamuliza et al. (2024) found that Rwandan chemistry teachers valued simulations while limited computers and insufficient training constrained their use. The Mkuranga evidence also aligns with Msafiri et al.'s (2023) synthesis, which treats equipment, training, technical support, leadership, and curricular alignment as a system rather than isolated inputs. Agreement across survey, interview, and observation data strengthens the inference that school support was consequential for enactment even though its statistical relationship with attitude was weak.

The findings differ from Rimba and Tarmo's (2025) evidence from nearby Kibaha District, where science and mathematics teachers held predominantly negative beliefs and beliefs strongly predicted reported ICT adoption. Several plausible, non-exclusive explanations exist. The Mkuranga study focused only on chemistry teachers, whose need to visualise abstract or hazardous processes may heighten perceived usefulness. Its attitude scores were also extremely positive in the dissertation—97.6% reported a positive attitude and 97.7% were willing to increase future use—creating a likely ceiling effect with little variance for school support to explain. The studies used different samples, measures, and outcomes, and the Mkuranga regression was small. These factors counsel against treating geographical proximity as methodological equivalence or interpreting the null result as a contradiction of all belief–use research.

TPACK and XK provide the strongest theoretical explanation. The teachers' positive evaluations suggest an appreciation of how technology can support chemistry content and pedagogy, but contextual knowledge includes recognising whether devices, time, connectivity, maintenance, leadership arrangements, and training make a planned activity feasible (Mishra, 2019). The weak support–attitude relationship therefore does not undermine TPACK. It indicates that context may operate mainly at the transition from knowledge and intention to enacted practice. This interpretation complements Bai et al.'s (2024) finding that TPACK, self-efficacy, and attitude contribute to behavioural intention, while adding that intention can be blocked downstream by institutional conditions. It also supports Shambare and Jita's (2024) call for targeted development of technology-related

TPACK domains in rural science education.

The professional-development finding deserves particular attention. Generic encouragement from school leaders was widespread, but regular training was not. Moosa and Ramnarain (2023) showed that sustained, participatory professional development can improve physical-science teachers' attitudes and intentions. In Mkuranga, however, attitude enhancement alone is unlikely to yield the largest marginal benefit because willingness was already near the top of the scale. Training should instead be chemistry-specific and practice-centred: selecting offline and low-bandwidth resources, using simulations and virtual laboratories, designing multimedia explanations of microscopic processes, managing digital assessment, troubleshooting common failures, and preparing non-digital fallbacks. The 15 secondary-teacher ICT modules being developed by UNESCO and the Tanzania Institute of Education provide a timely national platform, but their impact will depend on subject adaptation, access, mentoring, and school-level follow-through (UNESCO, 2025).

The study has limitations. It was a small, cross-sectional case study of public schools in one district, so the regression cannot establish causality and the results should not be generalised mechanically to private schools or all Tanzanian regions. Attitudes and school conditions were partly self-reported, and observed lessons covered a limited period. The very high attitude scores may have reduced detectable variance, while the regression used only 43 complete cases. Most importantly, the absence of realised reliability coefficients and an identifiable ethics approval reference prevents full appraisal of measurement quality and governance. These details should be supplied before journal submission. Even with these constraints, triangulation across survey, interview, and observation data provides coherent evidence that Mkuranga's main challenge is converting favourable attitudes into feasible, repeatable classroom practice.

CONCLUSION AND RECOMMENDATIONS

Chemistry teachers in Mkuranga District valued ICT and were willing to expand its use, but the schools did not consistently provide the conditions required to translate that willingness into instruction. Reliable electricity and supportive leadership represented important foundations, yet inadequate equipment, irregular professional development, limited technical assistance, unstable connectivity, and weak maintenance restricted classroom enactment. The school-support composite did not significantly predict attitude, but qualitative and observational evidence showed that support shaped access and implementation. The study therefore concludes that positive attitude is an enabling condition, not a sufficient intervention or an adequate proxy for actual integration.

Policy and practice should shift from awareness-raising alone to an implementation package. The Ministry of Education, Science and Technology and PO-RALG should fund equitable provision of functional computers, projectors, offline-capable chemistry resources, stable connectivity, virtual-laboratory access, maintenance, and district-level technical personnel. School leaders should protect time for recurring, hands-on professional learning, organise peer mentoring, track equipment availability and use, and budget for repair rather than waiting for devices to fail. Teacher-education institutions and continuous-professional-development providers should embed chemistry-specific TPACK in training and assess teachers through designed lessons and observed practice, not attendance alone. Future research should use larger multi-district samples, validated scales with reported reliability estimates, longitudinal or intervention designs, and measures of actual classroom use and student learning. Such work would test whether improvements in infrastructure and chemistry-focused professional development close the gap between teachers' positive attitudes and sustained ICT-supported teaching.

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