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(RESEARCH ARTICLE)

Assessing Secondary School Teachers' Digital Competence for Competency-Based Education Implementation in Bungoma County, Kenya: A TPACK-Based Study

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Abstract

Kenya's shift to Competency-Based Education (CBE) assumes teachers can translate ICT tool access into learner competency development. This study assessed the level of teacher digital expertise in CBE implementation to establish whether this assumption is empirically warranted. A concurrent mixed-methods case study was conducted in public secondary schools in Bungoma County, Kenya. An 11-item Technological Pedagogical Content Knowledge (TPACK) scale, extended with a Digital Self-Efficacy (DSE) dimension, was administered to 190 teachers (97.9% response rate) drawn from 43 stratified-sampled schools, and triangulated with 40 structured classroom observations and 35 key informant interviews. Data were analysed using descriptive statistics, Principal Component Analysis (PCA), and thematic analysis. Teachers reported moderate proficiency across all four domains (M = 2.83–3.01, five-point scale), with Digital Self-Efficacy the weakest (M = 2.68–2.88) and Content Knowledge the strongest. Over half of teachers (55.8%) had received no formal ICT training or only short, disconnected courses. PCA extracted a single dominant component explaining 86.80% of variance (KMO = .962; Bartlett's $\chi^2(55) = 3362.24$, $p < .001$; loadings .904–.949), indicating that the four TPACK domains function as one interdependent construct rather than separable skills. Teachers themselves identified their own digital capacity (60.3%), not infrastructure, as the dominant barrier to effective ICT use, and prioritised sustained professional development (62.5%) over equipment provision. Professional development in CBE contexts should be redesigned as an integrated, school-embedded programme that builds technical, pedagogical, content, and confidence-related competencies simultaneously, with deliberate attention to Digital Self-Efficacy, rather than as isolated technical-skills workshops. This study extends TPACK with an empirically validated Digital Self-Efficacy dimension and provides one of the few PCA-based demonstrations that teacher digital expertise operates as a unified rather than additive construct in a Sub-Saharan African CBE setting, offering an evidence base rarely available for policy design in the region.

Keywords: Teacher Digital Expertise; TPACK; Digital Self-Efficacy; Competency-Based Education; Teacher Professional Development

1. Introduction

Kenya's transition to Competency-Based Education (CBE) has repositioned the teacher as the central agent through whom curriculum policy is translated into classroom practice capable of developing learner competencies rather than mere content recall (Kenya Institute of Curriculum Development [KICD], 2023). Within this reform, information and communication technology (ICT) is promoted as a critical enabler of learner-centred, competency-oriented instruction. However, a growing body of evidence indicates that the presence of ICT infrastructure in schools does not, by itself, guarantee meaningful pedagogical use; the outcome depends substantially on whether teachers possess the knowledge, skills, and confidence required to deploy available tools purposefully in the classroom (Smidt & Edwards, 2023; UNESCO, 2023). This capacity is described in this paper as teacher digital expertise.

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Despite the centrality of this assumption to CBE policy, empirical evidence on the specific level and internal structure of teacher digital expertise in Kenyan classrooms remains limited, and existing regional studies rarely test whether the knowledge domains theorised by the Technological Pedagogical Content Knowledge (TPACK) framework actually behave as distinct, separable competencies in practice, or instead function as a single, interdependent capacity that must be developed holistically. This is not a minor measurement question: if the domains are separable, targeted single-domain training (for example, technical skills workshops) should be sufficient; if they are unified, such training will systematically under-deliver. This paper addresses that gap directly.

This paper is drawn from a broader mixed-methods study of ICT Tools Usability, Teacher Digital Expertise, and Learner Competency Attainment in Kenyan CBE implementation (Rotich, 2026), which developed and validated an integrative ICT-UTEL framework. The parent study's inferential findings show that teacher digital expertise, and not ICT usability alone, is the dominant predictor of learner competency outcomes; understanding its current level, internal structure, and constraints is therefore a necessary empirical foundation for designing effective interventions. This paper isolates and reports that assessment in full, addressing the research question: What is the level, structure, and self-reported constraint profile of teacher digital expertise among secondary school teachers implementing CBE in Kenya?

Framed by TPACK (Mishra & Koehler, 2006) and extended with Digital Self-Efficacy (DSE) as a fourth dimension consistent with Smidt and Edwards's (2023) affective-motivational proposition, the paper presents empirical evidence on the proficiency of secondary school teachers in Bungoma County, Kenya, across Technology Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), and DSE, tests the internal structure of these domains through Principal Component Analysis, and discusses the implications of the findings for CBE implementation in Kenya and comparable Sub-Saharan African contexts.

2. Literature Review and Theoretical Framework

2.1. Conceptualising Teacher Digital Expertise

Teacher digital expertise is defined in this study as the integrated set of knowledge, skills, attitudes, and confidence necessary for teachers to incorporate ICT tools into lesson planning, instruction, assessment, and monitoring of learner competency attainment in CBE classrooms (Smidt & Edwards, 2023). The TPACK framework (Mishra & Koehler, 2006) conceptualises effective technology-enhanced teaching as arising from the intersection of Technology Knowledge, Pedagogical Knowledge, and Content Knowledge, and stresses that these domains are intersectional rather than additive: weakness in any one domain constrains the effective expression of the others in classroom practice. A teacher with strong Content and Pedagogical Knowledge but weak Technology Knowledge, for instance, will struggle to translate well-designed lessons into ICT-supported execution, while a teacher with strong Technology Knowledge but weak Pedagogical Knowledge may confine ICT use to content presentation rather than competency development.

This study extends TPACK by incorporating Digital Self-Efficacy as a fourth operational dimension, following Smidt and Edwards's (2023) finding that affective-motivational confidence is as consequential as cognitive knowledge in determining whether teachers sustain ICT integration under the practical constraints of classroom conditions. A systematic review of TPACK in pre-service teacher education spanning 2014–2024 similarly found that TPACK remains the most widely adopted framework for understanding technology integration, and that weaknesses in any single domain reliably constrained integration quality across contexts. In a Sub-Saharan African context directly relevant to this study, a review of interactive technologies in African teacher education found that teachers' digital pedagogical content knowledge, an extension of TPACK, mediated the relationship between technology availability and student achievement, with teacher self-efficacy emerging as a critical moderating variable (Oubibi et al., 2024).

2.2. The Professional Development Deficit in Sub-Saharan Africa

The professional development context in Sub-Saharan Africa compounds the teacher digital expertise deficit. UNESCO (2023) documented that professional development in digital education across the region is characteristically delivered as short, infrequent workshops disconnected from classroom practice, a design that builds awareness but fails to develop the situated competence CBE demands. Consistent with this, a Kenyan study of ICT integration found that professional development programmes were most effective when they incorporated practical activities, peer collaboration, and sustained follow-up coaching, conditions largely absent from ICT training delivered to Kenyan secondary school teachers (Ngaya et al., 2024). This evidence base directly informs the present study's assessment of teacher digital expertise across TPACK domains.

2.3. ICT, Teacher Expertise, and Learner Competency Outcomes

Research on the relationship between ICT integration and learner competency outcomes is neither simple nor unidirectional. Gauthier and Theilmann (2023) and the Organisation for Economic Co-operation and Development [OECD] (2024) found that ICT integration improved digital literacy, communication, and collaboration competencies when teachers specifically designed activities for competency development. Conversely, Zhang and Chen (2024) caution, through a meta-analysis, that ICT can increase cognitive load and reduce attainment when tools are poorly matched to learning objectives or when teacher facilitation is inadequate. These apparently contradictory findings converge on a single conclusion: the educational effect of ICT on learner competency outcomes is mediated by teacher digital expertise. It is this convergent proposition that positions teacher digital expertise, rather than ICT availability, as the central explanatory variable examined in this paper.

Within Kenya specifically, Ngaya et al. (2024) and Omariba (2023) confirm that ICT integration is constrained less by the absence of tools than by teachers' functional capacity to deploy them meaningfully. This body of literature establishes the rationale for empirically assessing, rather than assuming, the level of teacher digital expertise among practising CBE teachers, which is the task undertaken in this paper.

2.4. Research Gap and Positioning of the Study

Three gaps in the reviewed literature motivate this study. First, most Kenyan studies of ICT integration measure general digital literacy or infrastructure access rather than TPACK-specific, domain-disaggregated teacher expertise (Ngaya et al., 2024; Omariba, 2023). Second, few studies test empirically whether TPACK's theorised domains behave as separable or unified constructs, despite this having direct implications for professional development design. Third, the affective-motivational dimension of technology integration — self-efficacy — is rarely measured alongside cognitive TPACK domains in African contexts, despite evidence that it may be the more behaviourally decisive factor (Smidt & Edwards, 2023; Oubibi et al., 2024). This paper addresses all three gaps by disaggregating teacher digital expertise into four measurable domains, testing their internal structure through PCA, and triangulating self-report proficiency data with independent classroom observation and interview evidence.

3. Materials and Methods

3.1. Research Design and Case

This paper reports the component of a concurrent mixed-methods case study addressing teacher digital expertise within a broader study of ICT usability, teacher digital expertise, and learner competency attainment (Creswell & Creswell, 2023). The case was defined as public secondary schools implementing the Competency-Based Curriculum in Bungoma County, Kenya. The concurrent design allowed quantitative proficiency data to be interpreted alongside independently collected observational and interview evidence within the same data collection cycle, strengthening inferential confidence beyond what any single method could provide.

3.2. Population, Sampling, and Participants

A three-stage sampling design combining stratified and systematic sampling was applied. The 431 public senior secondary schools in Bungoma County were stratified by the county's nine constituent sub-counties, and a 10% stratified systematic sample yielded 43 schools. Teacher respondents were sampled using Yamane's (1967) formula, $n = N / (1 + Ne^2)$, with a 7% margin of error adopted to balance statistical precision against logistical feasibility across a geographically dispersed sample, yielding a target of 194 teachers and a final achieved sample of 190 respondents (97.9% response rate). Classroom observations were conducted in 40 of the 43 sampled schools, and semi-structured interviews were conducted with 35 key informants (school principals, deputy principals, ICT heads, and curriculum support officers).

3.3. Instrumentation and Measures

Teacher digital expertise was measured using an 11-item questionnaire scale spanning four TPACK-based domains: Technology Knowledge (3 items), Pedagogical Knowledge (3 items), Content Knowledge (3 items), and Digital Self-Efficacy (2 items), rated on a five-point proficiency scale (1 = Not Proficient to 5 = Highly Proficient). This self-report instrument was triangulated with a structured classroom observation checklist capturing directly observed technology-related teaching behaviours, and a semi-structured key informant interview guide, reducing reliance on single-source, self-report data and mitigating common method bias (Podsakoff et al., 2003).

3.4. Validity and Reliability

Content and face validity were established through expert review. The scale demonstrated good internal consistency in pilot testing conducted in Uasin Gishu County, a county selected for its comparable socio-infrastructural profile but excluded from the main sample (Cronbach's α = .87), exceeding the recommended .70 threshold (Andrade, 2023).

3.5. Data Analysis

Quantitative data were analysed using descriptive statistics (means and percentage distributions) to characterise proficiency at item and domain level. Principal Component Analysis (PCA), with Kaiser–Meyer–Olkin (KMO) and Bartlett's Test of Sphericity diagnostics, was used to test the internal structure of the 11-item scale and to establish whether the four theorised TPACK domains behaved as separable or unified constructs. Qualitative data from key informant interviews, classroom observation notes, and open-ended questionnaire items were analysed thematically following Braun and Clarke's (2006) six-phase approach, and used to corroborate and contextualise the quantitative proficiency and construct findings.

3.6. Ethical Considerations

The study was conducted under institutional ethical approval, with written informed consent obtained from all teacher and key-informant participants prior to data collection. Participation was voluntary, anonymity and confidentiality were assured in data reporting, and no learner-level data were collected as part of this specific objective.

4. Results

Table 1 summarises teachers' highest level of formal ICT training, which provides essential context for interpreting the proficiency findings that follow.

Table 1 Highest ICT Training Attained by Sampled Teachers (N = 190)

ICT Training Level	Frequency	Percent (%)
None	43	22.6
Short Course(s)	63	33.2
Certificate	17	8.9
Diploma	20	10.5
Degree	45	23.7
Postgraduate	2	1.1
Total	190	100.0

Source: Author research data (2026).

A combined 55.8% of teachers had received no formal ICT training (22.6%) or only short courses (33.2%), representing a substantial professional development deficit consistent with UNESCO's (2023) documentation of teacher capacity as the primary constraint on ICT integration in Sub-Saharan Africa. Only 24.8% of teachers had attained degree-level or postgraduate ICT training. This training profile is directly relevant to interpreting the proficiency findings across the four TPACK domains reported below.

4.1. Teacher Technology Knowledge

Table 2 Teacher Technology Knowledge Proficiency

Statement	Not Prof. (%)	Slightly (%)	Moderately (%)	Proficient (%)	Highly (%)	M
Setting up, operating and troubleshooting ICT hardware/software	28.4	13.9	17.5	26.8	13.4	2.83
Managing files and using storage solutions (local and cloud)	20.6	16.0	21.6	27.3	14.4	2.99
Navigating learning platforms and subject-specific applications	24.7	9.8	26.8	24.7	13.9	2.93

Source: Author research data (2026).

Technology Knowledge scores ranged from M = 2.83 to 2.99, indicating moderate proficiency overall. Hardware and software troubleshooting registered the lowest score (M = 2.83), with 42.3% of teachers rating themselves as not proficient or only slightly proficient. This is the most consequential Technology Knowledge deficit in terms of classroom impact, since teachers who cannot independently resolve basic technical problems are compelled to abandon ICT activities when problems arise, directly curtailing opportunities for learner competency development. File management registered the highest score (M = 2.99), suggesting that basic digital literacy foundations are comparatively stronger than advanced technical troubleshooting competencies.

4.2. Teacher Pedagogical Knowledge

Table 3 Teacher Pedagogical Knowledge Proficiency

Statement	Not Prof. (%)	Slightly (%)	Moderately (%)	Proficient (%)	Highly (%)	M
Designing ICT-driven, learner-centred CBE lessons	23.7	17.0	19.6	26.3	13.4	2.89
Facilitating learner collaboration and inquiry using digital tools	23.2	15.5	21.1	24.2	16.0	2.94
Selecting digital activities that match intended CBC competencies	21.6	16.5	21.1	28.9	11.9	2.93

Source: Author research data (2026).

Pedagogical Knowledge scores ranged from M = 2.89 to 2.94. Designing ICT-driven, learner-centred CBE lessons registered the lowest score (M = 2.89), with 40.7% of teachers rating themselves as not proficient or slightly proficient. This finding is significant because lesson design is the entry point for competency-driven ICT integration: teachers who cannot design learner-centred ICT lessons will default to passive, presentation-led technology use regardless of tool availability, consistent with TPACK's proposition that effective technology integration requires the intersection of Technology Knowledge with Pedagogical Knowledge, since proficiency in one domain alone is insufficient (Mishra & Koehler, 2006).

4.3. Teacher Content Knowledge

Table 4 Teacher Content Knowledge Proficiency

Statement	Not Prof. (%)	Slightly (%)	Moderately (%)	Proficient (%)	Highly (%)	M
Aligning ICT use with specific CBC subject competencies	19.6	21.6	18.6	24.7	15.5	2.95
Using ICT to set performance tasks and track learner competency progress	14.4	25.8	22.2	25.3	12.4	2.95
Giving timely digital feedback to learners	15.5	20.1	27.3	22.2	14.9	3.01

Source: Author research data (2026).

Content Knowledge was the strongest of the four TPACK domains (*M* range 2.95–3.01). Timely digital feedback received the highest rating (*M* = 3.01), suggesting that this application was the most straightforward for teachers to execute. That Content Knowledge was marginally stronger than Technology and Pedagogical Knowledge suggest that teachers possess a clearer sense of the subject competency goals (the *what*) than of the technological and pedagogical strategies required to achieve them through ICT (the *how*), consistent with KICD (2023), which emphasises that competency-based assessment using ICT requires targeted and continuous professional support.

4.4. Teacher Digital Self-Efficacy

Table 5 Teacher Digital Self-Efficacy Proficiency

Statement	Not Prof. (%)	Slightly (%)	Moderately (%)	Proficient (%)	Highly (%)	M
I am confident using ICT tools independently without a technician	19.6	18.0	18.6	26.3	17.5	2.88
I adapt digital tools for varied CBE activities when challenges arise	17.5	23.2	19.6	22.7	17.0	2.68

Source: Author research data (2026).

Digital Self-Efficacy was the weakest of the four TPACK domains. More than one-third of teachers (37.6%) reported lacking confidence in using ICT independently without technician support, and 40.7% reported difficulty adapting tools when classroom challenges arose. Classroom observations corroborated these self-assessments: in approximately 45% of observed lessons in which technical problems arose, teachers chose to abandon the ICT activity rather than adapt or troubleshoot independently. Key informants described the affective dimension of this deficit, noting that teachers often feel unable to resolve a mid-lesson technical challenge in front of their class. This finding underscores Smidt and Edwards's (2023) conclusion that teacher confidence is a stronger predictor of sustained technology integration than technical skill alone, and identifies Digital Self-Efficacy as the domain of greatest practical concern for CBE implementation.

4.5. The Unified Structure of Teacher Digital Expertise

Principal Component Analysis was conducted on the 11 Teacher Digital Expertise items to establish their underlying dimensional structure. Sampling adequacy was excellent (KMO = .962, classified as “marvellous” by Kaiser's [1974] criteria), and Bartlett's Test of Sphericity was highly significant ($\chi^2(55) = 3362.24$, $p < .001$), confirming the data were suitable for factor extraction.

Table 6 Total Variance Explained for Teacher Digital Expertise Items

Component	Initial Eigenvalue	% of Variance	Cumulative %
1	9.548	86.80	86.80
2	.296	2.70	89.50
3	.246	2.24	91.73
4	.191	1.73	93.46
5–11	< .140	< 1.26 each	100.00

Source: Author research data (2026); extraction method: Principal Component Analysis.

Table 7 Component Matrix for Teacher Digital Expertise Items (N = 190)

Domain	Item	Loading
PK	Facilitating learner collaboration and inquiry using digital tools	0.949
PK	Selecting digital activities that match intended CBC competencies	0.943
TK	Setting up, operating and troubleshooting ICT hardware/software	0.940
PK	Designing ICT-driven, learner-centred CBE lessons	0.939
CK	Aligning ICT use with specific CBC subject competencies	0.938
TK	Navigating learning platforms and subject-specific applications	0.935
DSE	Confident using ICT tools independently without a technician	0.934
TK	Managing files and using storage solutions (local and cloud)	0.928
DSE	Adapting digital tools for varied CBE activities when challenges arise	0.925
CK	Using ICT to set performance tasks and track learner competency progress	0.915
CK	Giving timely digital feedback to learners	0.904

Note. Average loading = .932. Extraction method: Principal Component Analysis; one component extracted, rotation not performed. Source: Author research data (2026).

A single component with an eigenvalue greater than 1 was extracted, explaining 86.80% of total variance in Teacher Digital Expertise, with all 11 items loading strongly on this single component (loading range .904–.949; average loading = .932). This result empirically validates TPACK's foundational theoretical claim that Technology Knowledge, Pedagogical Knowledge, Content Knowledge, and Digital Self-Efficacy are deeply interdependent rather than independent dimensions of teacher digital expertise: a deficit in any one domain, particularly Digital Self-Efficacy, constrains the effective expression of the others in classroom practice. This finding has direct practical implications, since it indicates that professional development interventions addressing technical skills in isolation, without simultaneously building teacher confidence and pedagogical application, are unlikely to produce meaningful improvements in classroom ICT integration.

4.6. Teachers' Own Assessment of Barriers and Support Needs

Table 8 Teacher-Identified Barriers and Preferred Support for Effective ICT Use

Category	Greatest barrier (%)	Most valued support (%)
Teacher digital skills / capacity or training & CPD	60.3	62.5
Inadequate devices/equipment or device provision	19.1	9.9
Technical support / maintenance	6.7	15.1
ICT policy / leadership support	6.7	7.8
Internet / connectivity	7.2	4.7

Source: Author research data (2026).

When asked to identify the single greatest barrier to effective ICT use for learner competency development, teachers overwhelmingly cited their own digital skills and capacity (60.3%), more than three times the frequency of the next most common barrier, inadequate devices or equipment (19.1%). Connectivity issues (7.2%) and the absence of ICT policy or leadership support (6.7%) were cited far less frequently. This self-assessment is strategically significant: it shows that teachers themselves, not only researchers, recognise their own digital capacity as the primary bottleneck to effective ICT-enabled competency development, indicating a high degree of receptivity to well-designed professional development interventions. Correspondingly, when asked what form of support would most improve their practice, teacher training, continuing professional development, and workshops were the most valued response by a wide margin (62.5%), well ahead of technical support and maintenance (15.1%) or provision of additional devices (9.9%). This close alignment between the identified barrier and the preferred solution provides a strong evidential basis for prioritising sustained, competency-focused professional development.

5. Discussion

5.1. A Uniformly Moderate, Not Domain-Specific, Deficit

The finding that all four TPACK domains cluster narrowly around a moderate mean (M = 2.83–3.01) rather than showing sharp domain-specific strengths or weaknesses is itself analytically important: it suggests that Kenyan secondary teachers' digital expertise deficit is systemic rather than confined to a single, easily remediated skill gap. This reading is reinforced directly by the PCA result: the collapse of all 11 items onto a single component explaining 86.8% of variance indicates that, statistically as well as descriptively, these domains behave as one construct in this sample. Practically, this means that improving Technology Knowledge alone — the most common focus of short ICT training courses in the region (UNESCO, 2023) — will not proportionately improve Pedagogical or Content Knowledge, nor Digital Self-Efficacy, because these are not independent levers.

5.2. Digital Self-Efficacy as the Behaviourally Decisive Domain

Although Digital Self-Efficacy was the weakest domain by only a small numerical margin, its behavioural consequences were disproportionately large: classroom observation data show that in approximately 45% of lessons where technical problems arose, teachers abandoned the ICT activity entirely rather than adapting or troubleshooting. This pattern indicates that the practical cost of low self-efficacy is not merely a modestly lower proficiency score but a binary loss of the entire competency-development opportunity that the lesson was designed to deliver. This extends Smidt and Edwards's (2023) proposition that confidence is a stronger predictor of sustained technology integration than technical skill alone into a Kenyan CBE setting, and offers a theoretical refinement to TPACK: affective-motivational capacity may function less as a fourth co-equal domain and more as the switch that determines whether cognitive-knowledge domains are expressed in practice at all.

5.3. Comparison with the Broader Sub-Saharan African Literature

These findings align closely with Oubibi et al.'s (2024) Sub-Saharan African finding that teacher self-efficacy moderates the relationship between technology availability and student achievement, and with UNESCO's (2023) documentation of short, disconnected professional development as the regional norm. The present study extends this literature by providing domain-disaggregated, PCA-validated evidence from a Kenyan CBE context specifically, and by empirically demonstrating — rather than theoretically asserting — that TPACK's domains function as a unified construct in this setting, a claim seldom tested statistically in African teacher-expertise research.

5.4. Practical and Policy Implications

The convergence between the quantitative deficit profile and teachers' own qualitative diagnosis — that their digital skills, not infrastructure, are the primary barrier, and that sustained training, not equipment, is their most valued form of support — provides an unusually strong evidential basis for policy prioritisation. It indicates that Kenyan teachers themselves recognise digital capacity as the binding constraint, suggesting a workforce that is receptive to, rather than resistant to, well-designed professional development interventions. This finding cautions against policy responses that privilege infrastructure investment over professional development, a risk flagged in the broader Sub-Saharan African literature (UNESCO, 2023).

Limitations

Three limitations qualify these findings. First, proficiency data were predominantly self-reported; although triangulated with classroom observation and interview evidence, self-report may be subject to social desirability bias. Second, the

study was conducted in a single Kenyan county, and while Bungoma County's urban–rural and infrastructural diversity supports analytical transferability, the findings should not be generalised to Kenya as a whole without further replication. Third, the cross-sectional design captures teacher digital expertise at a single point in time and cannot establish whether the unified TDC structure identified here is stable over time or would fragment following domain-specific interventions; this is an important direction for future longitudinal research.

6. Conclusion

This paper set out to assess the level of teacher digital expertise in the implementation of Competency-Based Education in Kenya. The evidence shows that teacher digital expertise among the sampled secondary school teachers in Bungoma County is moderate at best across all four TPACK-based domains, with Digital Self-Efficacy consistently the weakest and most behaviourally consequential deficit. More than half of the teachers sampled had received no formal ICT training or only short, disconnected courses, representing a large-scale professional development gap that directly explains observed classroom behaviour, including the frequent abandonment of ICT activities when technical problems arise. Principal Component Analysis confirmed that the four TPACK domains operate as a single, highly unified construct rather than as separable competencies, meaning that interventions targeting only one domain, such as technical skills training alone, are unlikely to substantially improve teachers' overall digital expertise or its translation into competency-based instruction.

Because teacher digital expertise has been shown in the broader parent study to be the dominant driver of learner competency attainment, considerably outweighing the independent contribution of ICT tools usability, the moderate and self-efficacy-constrained level of expertise documented here represents the most consequential bottleneck to effective CBE implementation in Kenyan secondary schools. Strengthening this expertise, particularly its confidence dimension, should therefore be treated as a central priority in national and institutional efforts to improve ICT-enabled competency-based education.

Recommendations

- Policy

The Teachers Service Commission, in partnership with the Kenya Institute of Curriculum Development and the Kenya Education Management Institute, should redesign both pre-service and in-service teacher professional development to embed ICT integration competencies aligned with TPACK and CBC requirements as non-negotiable certification standards.

- Practice

In-service development should transition from isolated short courses, shown here to be insufficient, to sustained, school-embedded programmes that develop Technology, Pedagogical, and Content Knowledge together with Digital Self-Efficacy in an integrated manner, incorporating mentorship and peer learning communities. Particular attention should be given to deliberately building Digital Self-Efficacy through graduated, low-stakes, supported classroom ICT practice, recognising that teacher confidence is built through repeated successful experience rather than awareness-based training alone. School administrators should also institute responsive, on-site technical support structures so that teachers experiencing mid-lesson technical difficulties are not compelled to abandon ICT-based competency activities, since observed abandonment behaviour was closely tied to low self-efficacy rather than to tool unavailability.

- Future Research

Future research should track teacher digital expertise longitudinally following the implementation of sustained professional development interventions, to establish whether such interventions produce measurable gains in the Digital Self-Efficacy domain specifically, and to test whether the unified Teacher Digital Competence structure identified here replicates across other Kenyan counties, school types, and Sub-Saharan African education systems.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

Kibabii University Institutional Scientific and Ethics Review Committee Approval granted clearance for this study.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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