

DEVELOPING WORK-RELEVANT DIGITAL COMPETENCIES IN RURAL SECONDARY EDUCATION: INSIGHTS FROM HOMA BAY, KENYA

Vivian Harberts¹, Julian Ng², Peter Kaune¹, & Andreas Saniter¹

¹*Institute Technology and Education, University of Bremen (Germany)*

²*Warnborough College (Ireland)*

Abstract

The growing demand for digitally competent employees in rural Kenya contrasts sharply with the limited technological resources and digital training capabilities in rural schools. While Kenya's Competency Based Curriculum (CBC) represents an important government initiative to integrate digital skills into education, its implementation faces significant challenges in rural areas where schools struggle with insufficient ICT infrastructure, limited teacher digital competencies, and minimal student access to technology. This mixed-methods study examines the critical gap between industry requirements and educational capacity in Homa Bay County, investigating how these limitations impact workforce readiness and local economic development. The study addresses four central research questions: (1) What is the gap between industry-required digital competencies and existing digital skills among teachers and students in rural schools? (2) How do current ICT competency levels compare against the DigComp framework? (3) What barriers and opportunities affect the development of work-relevant digital competencies? (4) What strategies could address these challenges? The research draws on data collected across three secondary schools and ten local industries. The methodology combined surveys of teachers' and students' digital competencies aligned with the DigComp framework, industry needs analyses, technical assessments of school ICT infrastructure, and an analysis of CBC implementation challenges. Results reveal significant misalignments between CBC objectives, current educational capacities, and industry needs, including how the digital competency gap affects both CBC implementation and workforce development in rural contexts. Accordingly, a digital teaching strategy was implemented combining solar-powered ICT infrastructure, low-energy digital devices, and a structured teacher development programme aligned with both DigComp and CBC requirements. The strategy emphasises practical applications through Learning and Work Tasks integrating real-world industry problems.

Keywords: *Digital competencies, work-based learning, rural education, teacher development, educational technology.*

1. Introduction

Digital competence is now a fundamental prerequisite for workforce participation across economic sectors worldwide. In Kenya, the government responded to this imperative through two interconnected policy reforms: introducing the Competency Based Curriculum (CBC) and in 2017, restructuring the education system from the 8-4-4 framework to a 2-6-3-3-3 model, explicitly mandating technology integration in learning at all levels (Ministry of Education Republic of Kenya, 2018; Kenya Institute of Curriculum Development, 2023).

Homa Bay County in western Kenya exemplifies this divergence. Its 2015 ICT Roadmap articulated a vision for digital transformation. Yet, by 2018, the County Integrated Development Plan documented a near-total absence of internet access in rural sub-counties, a county ICT department of only six staff members, and a mobile phone penetration of 85.6% alongside practically no fixed-line services (County Government of Homabay, 2018). Regional studies confirm that 44% of public primary schools in the county had no ICT-trained teacher (Kembo et al., 2019), with comparable deficits in secondary schools.

Conversely, the county's labour market is evolving. The growing services sector in banking and telecommunications is generating employer demand for digitally competent graduates, a demand that the current school system does not meet. This structural misalignment between educational output and labour market requirements has motivated the DEVISE4KE (Digital Education for Vocational and ICT Skills

Enhancement in Kenya) project which targets three rural mixed secondary VET schools in the county: Kiabuya, Miramba, and St. Joseph Olando.

2. Theoretical and conceptual framework

This study integrates three frameworks to guide teacher development and curriculum design. The DigComp 2.2 framework (Vuorikari et al., 2022) serves as the primary analytical lens, defining digital competence across five areas: Information and Data Literacy, Communication and Collaboration, Digital Content Creation, Safety, and Problem-Solving. It enables standardised, international measurement of competency gaps from Foundation to Specialised levels.

Pedagogically, two complementary models inform the design of teacher development and classroom practice. The SAMR model (Puentedura, 2024) categorises technology integration into four levels (Substitution, Augmentation, Modification, Redefinition). The TPACK framework (Mishra & Koehler, 2006) identifies the essential intersection of Technological, Pedagogical, and Content Knowledge for effective teaching.

Learning and Work Tasks (LWTs) operationalize these frameworks didactically in classroom practice. Rooted in the University of Bremen's Kompetenzwerkstatt approach, LWTs place learners in authentic, problem-based scenarios drawn from real work or community contexts, structured across four phases: acceptance, planning, implementation, and conclusion. This approach is consistent with Kenya's CBC emphasis on practical, inquiry-based, and competence-oriented learning (Kenya Institute of Curriculum Development, 2023), and is particularly well-suited to the Homa Bay context because LWTs are designed to function with low-energy devices and offline content. This directly addresses the documented constraints.

3. Research design and methodology

This study employs a mixed-methods, design-based research (DBR) approach. DBR is appropriate where the aim is both to generate understanding of a problem in a specific context and to develop and refine an intervention in response to that problem (Anderson & Shattuck, 2012). Data were collected across two strands: a needs assessment strand and an implementation strand, the latter providing the evidence base for evaluating strategy design.

3.1. Needs assessment

Surveys were conducted over six months at the three previously-named secondary schools and ten local industries in Homa Bay County. 34 teachers across the three schools assessed self-reported digital competence across all five DigComp 2.2 dimensions using a four-point scale (1 = no knowledge; 4 = fully mastered). An additional module examined pedagogical dimensions against the DigCompEdu framework on teaching and learning, assessment, empowering learners, and facilitating learners' digital competence. A parallel student survey evaluated data on device access and competence levels.

Representatives from ten Homa Bay County companies in manufacturing, trade, banking, telecommunications, tourism, and agricultural services rated the importance of transversal skills and DigComp competence areas on a four-point scale (1 = not important; 4 = very important).

Technical infrastructure assessments were jointly conducted through on-site inspections at each school by Rongo University and the University of Bremen. Inspection protocols recorded structural conditions, electrical installations, sun exposure, and space for ICT room development. A photovoltaic feasibility analysis was subsequently conducted using NASA POWER Data Access Viewer and PV Watts data.

3.2. Scope and limitations

The industry sample (n = 10) and teacher sample sizes reflect the rural context and should be understood as locally contextualised qualitative-quantitative data rather than as statistically representative national samples. Findings are reported accordingly. The study design does not include a post-intervention competence measurement at the time of writing; learning outcome effects of the digital teaching strategy remain a subject for longitudinal follow-up research.

4. Findings

This study employs a mixed-methods, design-based research (DBR) approach. DBR is appropriate where the aim is both to generate understanding of a problem in a specific context and to develop and refine

an intervention in response to that problem (Anderson & Shattuck, 2012). Data were collected across two strands: a needs assessment strand and an implementation strand, the latter providing the evidence base for evaluating strategy design.

4.1. Research question 1: The industry–school digital competency gap

Industry survey results reveal a strong demand for digital skills, with 90% of respondents rating collaborative problem-solving as 'very important' and 80% prioritising continuous learning and safety. While industry also highly values information literacy (70%), a digital mindset (60%) and transversal skills such as adaptability and resilience, teacher surveys document critical deficiencies across all five DigComp areas, particularly in evaluating information credibility and managing digital identity. Digital content creation remains the most acute deficit, as the vast majority of teachers lack the confidence to perform category-specific tasks. Student results show an even deeper deficit due to a lack of device access and ICT-trained staff, a situation compounded by an attitudinal gap where employees perceive digital competencies as 'nice-to-have' rather than essential (Strategy Report Homa Bay, 2024).

4.2. Research question 2: DigiComp comparison

Mapping teacher self-assessment results against the DigComp proficiency scale (Foundation → Intermediate → Advanced → Specialised) reveals that across all five competence areas, the majority of teachers in the sample did not demonstrate proficiency beyond the Foundation level for most sub-competences, with partial exceptions in basic Information and Data Literacy. The DigComp teaching strategy for the project accordingly set Intermediate to Advanced (proficiency levels 3–4) as the target competence level for teachers before they proceed to develop student-facing content (Strategy Report Homa Bay, 2024). Table 1 summarises the documented gap across all three stakeholder groups:

Table 1. Competency Gap Summary by DigComp Area.

DigiComp Area	Industry (% very important)	Teachers (self-assessment)	Students (device access / competence)
Information & Data Literacy	70-80%	Moderate; fake-news evaluation and information organisation weak	No or minimal device access; low/no competence
Communication & Collaboration	60-80%	Basic email only; majority uncertain beyond that	No or minimal device access; low/no competence
Digital Content Creation	50-70%	Majority not confident; few demonstrate competence	No or minimal device access; low/no competence
Safety	80%	Weak area across respondents	No or minimal device access; low/no competence
Problem-Solving	60-80%	Not confident beyond basic level	No or minimal device access; low/no competence

Source: Strategy Report Homa Bay (DEVISE4KE, 2024); industry and teacher survey data.

4.3. Research question 3: Barriers and opportunities

Rural digital transformation faces three primary structural barriers: the absence of grid electricity at school sites, a near-total lack of ICT-trained teachers, and a deficit of secure physical infrastructure for device storage. These primary constraints are exacerbated by secondary barriers such as unreliable rural mobile data, environmental risks like dust and humidity, and severe financial limitations regarding equipment maintenance. However, significant opportunities exist, as the region's average of 5.27 peak sun hours per day and unshaded corrugated iron roofs provide ideal conditions for photovoltaic energy generation (NASA POWER Data, cited in Strategy Report Homa Bay, 2024). Moreover, the high local mobile phone penetration rate of 85.6% (County Government of Homabay, 2018) demonstrates basic device familiarity, while the CBC policy framework together with industry demand creates necessary institutional and economic incentives for project success. The CBC policy framework and industry demand for digital skills create institutional and economic incentives aligned with the project's objectives.

5. Digital teaching strategy

The digital teaching strategy developed in response to these findings integrates three interdependent components: energy infrastructure, ICT equipment, and a phased teacher development programme culminating in the co-creation of Learning and Work Tasks.

5.1. Infrastructure rationale

The photovoltaic feasibility analysis established a daily energy demand of 15.4 kWh for a functional ICT classroom, including a 20% safety margin, leading to an average monthly consumption of

407 kWh. Among the three evaluated system options, the 6.7 kW system (839 kWh/month) was selected to maximise direct solar usage and minimise battery dependency. This is essential given the limited access to technicians in rural Homa Bay (Strategy Report Homa Bay, 2024). For student hardware, a tablet-with-keyboard configuration was chosen over laptops or Raspberry Pi setups due to its superior energy efficiency (20 W per device), offline capability, and local technical support. This hardware pairs with an offline-first laboratory design, using a local intranet server to provide educational resources without requiring active internet connectivity.

5.2. Teacher development pathway

Because teacher competence is the primary pedagogical bottleneck, the strategy prioritises teacher development as a prerequisite for student-facing digital education. The DigComp framework was chosen over the more advanced DigCompEdu, to transform teacher mindsets about technology before they are expected to produce content for their students' (Strategy Report Homa Bay, 2024, p. 26). This was a strategic decision for teacher digital competence to precede and underpin teacher digital pedagogy.

The teacher development pathway operates in four stages. In Stage 1, teachers individually upskill digitally through completing free online courses and self-assessment to achieve Intermediate to Advanced proficiency (levels 3–4) across all five DigComp areas. Stage 2 engages teachers with Learning and Work Tasks as both learners (experiencing the pedagogy as students) and designers (developing tasks for their own classrooms). Stage 3 involves masterclass workshops (LTTAs) focused on innovative, interactive lesson design. Stage 4 implements a train-the-trainer model to build institutional capacity across the broader school faculty.

5.3. Learning and work tasks and the task-manager

LWTs act as the pedagogical core of the student-facing strategy, developed by the teachers at each school and featuring locally-relevant tasks e.g. renewable energy installation and ICT entrepreneurship. Four LWTs were developed and require students to move through four structured phases (acceptance, planning, implementation, and conclusion) to build vocational competences and transversal skills (problem-solving, communication, initiative, adaptability).

LWTs were created and delivered using the Task Manager, a web-based authoring and learning environment developed by the University of Bremen. It was chosen for DEVISE4KE because of its low entry barrier, scalable task complexity, and a bandwidth-efficient design using links rather than uploads. The Task Manager is freely accessible and can be hosted on each school's own server (DEVISE4KE project documentation, 2024/2025).

The LWT on photovoltaic system installation (D3.2) exemplifies this integration: students use digital tools to simulate PV system performance and calculate energy generation, while simultaneously developing vocational competencies in system design, safety protocols, and maintenance — within a work-process-oriented task structure grounded in the real energy challenge facing their schools.

6. Discussion

The findings of this study contribute to the emerging body of research on digital education in resource-constrained rural contexts in sub-Saharan Africa in three substantive ways.

The tripartite gap between industry expectations, teacher competence, and student skills exceeds conventional supply-side accounts. A significant attitudinal dimension exists where employers view DigComp areas as essential while teachers and students perceive these as 'nice-to-have'. This indicates that effective strategy must address the perceived personal and professional relevance of digital. This challenge can be addressed through LWTs which grounded in authentic local contexts.

Secondly, the project's infrastructure design choices i.e., offline-first operation, solar energy autonomy, low-energy devices, offline-first content delivery, provides a transferable design logic for rural implementation. While most ICT-in-education interventions presuppose grid electricity and internet connectivity (Amutha, 2020; Das, 2019), the DEVISE4KE approach demonstrates that pedagogically functional, DigComp-aligned digital education is achievable within these constraints.

Thirdly, this strategy reflects a principled critique of top-down ICT rollouts by focusing on teacher development as a prerequisite, rather than a post-hoc consideration. Evidence on technology integration in education shows that teacher competence and confidence are stronger predictors of effective technology use than device availability (Mishra & Koehler, 2006; Punie & Redecker, 2017).

Outcomes from the DEVISE4KE teacher development programme show initial empirical support for this sequencing. Eighteen teachers (six per school) successfully completed the structured training pathway. They produced competence-based LWTs using the Task Manager platform. Notably, two sites had no ICT-trained teachers at the outset, suggesting the model works even under very constrained

conditions. Building on this, six of the teachers (two per school) are currently conducting student pilots using their self-developed LWTs (April–May 2026), with competence outcome evaluation at the time of writing.

Limitations of the current study warrant acknowledgement. The industry and teacher samples are locally contextualised and not statistically representative of Kenya as a whole. Additionally, while teacher development has yielded verifiable results, student competence data from ongoing pilots is not yet available, and the long-term sustainability of equipment and content maintenance remains untested.

7. Conclusion

The DEVISE4KE project addresses a severe multidimensional competence gap where industry demand for digital skills is high, but teachers face critical deficiencies and students lack device access. Structural barriers, including a lack of electricity and secure facilities, further constrain the implementation of Kenya's CBC reform.

The project's approach integrates solar-powered, offline-capable laboratories and a phased teacher development program grounded in DigComp 2.2. It treats teacher digital competence as a prerequisite for student education, by empowering 18 teachers to create and run competence-based LWTs based on authentic local vocational challenges and delivered through the Task Manager platform. Six teachers are now conducting a student pilot under evaluation (April–May 2026). Longitudinal research on student competence outcomes and the long-term sustainability of the model constitutes the next stage of the DEVISE4KE research programme.

References

- Amutha, D. (2020). The Role of ICT in Educational Development. *Journal of Educational Technology and Research*.
- Anderson, T., & Shattuck, J. (2012). Design-Based Research: A Decade of Progress in Education Research? *Educational Researcher*, 41(1), 16–25. <https://doi.org/10.3102/0013189X11428813>
- County Government of Homa Bay. (2018). *County Integrated Development Plan 2018–2022*. Homa Bay County Government.
- Das, K. (2019). The role and impact of ICT in improving the quality of education: An overview. *International Journal of Innovative Studies in Sociology and Humanities*, 4(6), 97–103.
- DEVISE4KE Consortium. (2024). *Strategy Report Homa Bay* [Internal Project Deliverable]. University of Bremen / Warnborough College Ireland / Maristak Durango / Rongo University. Erasmus+ Grant Agreement 101129102.
- DEVISE4KE Consortium. (2024/2025). *Project documentation: LWT concept and Task Manager description* [Internal Project Documents]. Erasmus+ Grant Agreement 101129102.
- Kenya Institute of Curriculum Development. (2023). *Competency Based Curriculum Framework*. Ministry of Education, Kenya.
- Kenya National Qualifications Authority. (2018). *Technical and Vocational Education and Training (TVET) Policy*. KNQA.
- Kembo, J., Omito, O., Ayere, M., & Ali, A. A. (2019). Teachers' Computer Capacity in Public Primary Schools in Homa Bay County, Kenya: The Case of the Digital Literacy Programme. *Journal of Education and Practice*.
- Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017–1054.
- Ministry of Education Republic of Kenya. (2018). *Competency Based Education and Training Policy Framework*. <https://www.education.go.ke/node/229>
- Punie, Y. (Ed.) & Redecker, C. (2017). *European Framework for the Digital Competence of Educators: DigCompEdu*. EUR 28775 EN. Publications Office of the European Union. doi:10.2760/178382
- Saravanakumar, A. R. (2018). Role of ICT on Enhancing Quality of Education. *International Journal of Innovative Science and Research Technology*, 3(12), 717–719.
- Vuorikari, R., Kluzer, S., & Punie, Y. (2022). *DigComp 2.2: The Digital Competence Framework for Citizens — With new examples of knowledge, skills and attitudes*. EUR 31006 EN. Publications Office of the European Union. doi:10.2760/115376
- Whittemore, S. (2018). *Transversal Competencies Essential for Future Proofing the Workforce*. WISE Research Series.

Note on sources: Data cited as 'Strategy Report Homa Bay (DEVISE4KE, 2024)' refers to the internal project deliverable compiled from primary data collected in the field. All other references are published external works. The DEVISE4KE project documentation (LWT concept, Task Manager description) refers to internal documents produced within the project.