I J I T I E

INTERNATIONAL JOURNAL OF INNOVATIVE TECHNOLOGY INTEGRATION IN EDUCATION

Volume 9, Issue 2, 2026

PROFESSIONAL CAPACITY BUILDING FOR ARTIFICIAL INTELLIGENCE INTEGRATION AMONG TECHNICAL AND VOCATIONAL EDUCATION TEACHERS IN NORTH EAST NIGERIA

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To cite this article:

Bukar, A. M., Abdullahi, S., Sani, M. & Omorilewa, A. M. (2026). Professional capacity building for artificial intelligence integration among technical and vocational education teachers in North East Nigeria. *International Journal of Innovative Technology Integration in Education (IJITIE)*, 9 (2), 148-162

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Article Info

Keywords

Artificial Intelligence,
Professional Capacity Building,
Technical and Vocational Education and Training,
Digital Competence,
Narrative Review,
North-East Nigeria

Abstract

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Abstract

Artificial Intelligence (AI) is changing teaching and learning and creating new professional learning demands for Technical and Vocational Education (TVE) teachers. This paper is a conceptual narrative review that considers literature-derived competencies and practical conditions relevant to AI integration in TVE, with particular attention to North-East Nigeria. A targeted search of Google Scholar and ERIC, together with official publications from UNESCO, the Federal Ministry of Education, the National Board for Technical Education, and UNICEF, was used to identify relevant literature and policy documents. Searches focused mainly on publications from 2016 to October 2026, while foundational sources were retained where necessary. The review considered sources addressing AI competency, teacher professional development, digital learning, TVET, Nigerian education policy, and education disruption in the North-East. The literature suggests that useful areas for professional development include AI literacy, AI-supported pedagogy, digital and simulation-based practical instruction, assessment and learning analytics, and responsible use of AI. Evidence on conflict-related education disruption in Borno, Adamawa, and Yobe highlights the difficult context in which education services operate; however, available regional data do not establish the AI competency levels of TVE teachers specifically. Accordingly, the competencies discussed are presented as a literature-derived framework rather than measured regional needs. The paper discusses infrastructure, funding, connectivity, professional learning opportunities, and institutional support as conditions that may shape implementation. It recommends sustained professional development, curriculum review, investment in reliable digital infrastructure, industry collaboration, and context-sensitive policy implementation. A local empirical needs assessment is required to determine the specific competence gaps of TVE teachers across North-East Nigeria.

Keywords: Artificial Intelligence, Professional Capacity Building, Technical and Vocational Education and Training, Digital Competence, Narrative Review, North-East Nigeria.

Introduction

Artificial Intelligence (AI) has emerged as an important technology in education, with applications across teaching, learning, assessment, and administration. However, the evidence base remains uneven, and the benefits and risks depend on how tools are selected and implemented (Chiu et al., 2023). Teachers therefore need to understand both the potential uses and the limitations of AI rather than assume that technology automatically improves learning.

Technical and Vocational Education (TVE) equips learners with practical skills, technical knowledge, and occupational competencies. Its workshop-based nature means that teachers must connect trade-specific content with appropriate teaching methods and technologies. Recent reviews of AI-competency frameworks emphasize that teachers need to understand AI capabilities and limitations, evaluate generated outputs, and apply ethical and pedagogical judgment when integrating AI into teaching (Mikeladze et al., 2024; Miao & Cukurova, 2024).

At the policy level, Pedró et al. (2019) discuss both the opportunities and challenges associated with AI in education. Bhimdiwala et al. (2022) specifically argue that fair and trustworthy AI implementation requires systematic collaboration among educators, researchers, and developers, with attention to the local context. These sources support a cautious, sensitive approach; they do not establish that AI has already improved learning outcomes in North-East Nigerian TVE institutions.

Much of the earlier AI-in-education literature has focused on higher education, as illustrated by the scope of the systematic review by Zawacki-Richter et al. (2019). A 2026 systematic review focused specifically on vocational education and training identified a small evidence base and reported that professional development was a critical issue in teachers' adoption of AI (Nakar et al., 2026). That review is international rather than specific to North-East Nigeria, so its findings provide focus rather than direct evidence of local teacher competence.

Against this background, this paper reviews literature and policy sources to develop a focus-sensitive framework for professional capacity building for AI integration among TVE teachers in North-East Nigeria. It does not report a new survey or claim to measure teachers' actual AI competence. The framework is intended to inform future empirical needs assessments and institutional planning.

Methodological Approach

This paper adopts a conceptual narrative review rather than an empirical survey or a systematic review. A targeted literature search was undertaken as the principal academic search, supplemented by targeted searches of official websites and publications from UNESCO, the Federal Ministry of Education, the National Board for Technical Education (NBTE), and UNICEF. Search phrases included artificial intelligence in TVET, AI competency framework for teachers, professional development of TVET teachers, digital competence of technical teachers in Nigeria, ICT in education policy Nigeria, and North-East Nigeria education insecurity and displacement. The search focused on material published from 2016 to October 2026; earlier foundational works were retained when they were central to the theoretical discussion. Sources were included when they addressed teacher AI/digital competence, TVET teacher development, Nigerian education policy, digital learning infrastructure, or documented education disruption in the North-East. Priority was given to peer-reviewed studies and official policy or humanitarian reports. Because this was a targeted narrative search, not a systematic review, the paper does not claim exhaustive coverage or a formal risk of bias assessment. The available literature was synthesized thematically around teacher competencies, implementation conditions, regional context, and capacity-building strategies.

North-East Nigerian Context and Available Evidence

North-East Nigeria comprises Adamawa, Bauchi, Borno, Gombe, Taraba, and Yobe States and includes universities, polytechnics, colleges of education, and technical and vocational institutions. These institutions operate within different regulatory and program arrangements; for example, NBTE publishes directories of accredited programs and policy resources for polytechnics and other TVET institutions (Bello, & Onyeocha,2023), while the National Commission for Colleges of Education (NCCE) has a statutory role in coordinating and assuring the quality of teacher education outside universities and polytechnics (Ogunode, & Adanna,2022). A regional inventory of institutions is useful for planning, but the existence of institutions does not establish the availability of AI enabled facilities or the competence of their teaching staff. A systematic institutional audit would be needed to compare staff qualifications, access to computers and software, connectivity, electricity reliability, and professional development opportunities across the six states.

There is some directly relevant evidence on digital skills and technology competence in the wider North-East/Northern Nigerian context. Umoru et al. (2024) examined digital skills competencies for the Professional Diploma in Education curriculum in vocational and technical education in North-East Nigeria and identified digital skills as a teacher education priority. Adamu et al. (2020) studied computer related competencies among TVE teachers in six tertiary technical institutions in Bauchi and Gombe. These studies are relevant to digital preparation, but they concern general digital/computer competencies rather than current generative-AI competence and should not be treated as representative assessments of all TVE teachers across the region. Internationally, Nakar et al. (2026) reviewed AI use in vocational education and found that the published empirical evidence remains limited and that professional development is a critical issue. Its findings are useful for framing questions, but cannot substitute for a local needs assessment.

Regional education disruption data provide important contextual evidence but must be interpreted carefully. UNICEF (2024) reported that insecurity had contributed to the closure of 113 schools in Borno, Adamawa, and Yobe during 2022 and 2023. UNICEF also reported substantial education access challenges and displacement in these states. These figures concern the broader school and education system and should not be misrepresented as statistics about TVE institutions or tertiary level teacher training. Nevertheless, conflict, displacement, damaged facilities, and restricted access can complicate continuity of education services and make sustained training provision more difficult. The regional evidence therefore justifies context sensitive planning, while leaving a clear research gap concerning the actual digital and AI competencies of TVE teachers in the six North-East states.

Theoretical Framework

This paper uses Technological Pedagogical Content Knowledge (TPACK) as its main framework. TPACK explains that effective technology integration requires teachers to combine content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK), including the intersections among them: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and integrated TPACK (Koh et al., 2015; Mishra & Koehler, 2006). For AI-supported TVE, teachers must not only know how to

operate a tool; they must decide whether it accurately represents a trade process, how it supports learning, and when direct workshop practice remains essential.

The framework is adapted here to the practical and practical, workshop based nature of TVE. CK includes trade specific concepts and procedures; PK includes demonstration, guided practice, project work, troubleshooting, and competency assessment; TK includes accessible digital devices, offline resources, and AI tools. PCK connects a trade concept to an appropriate teaching method, TCK connects AI or digital tools to trade content, and TPK considers how tools change demonstration, feedback, and assessment. TPACK represents the informed combination of all these domains for a specific lesson or practical task.

Recent AI focused teacher competency reviews foreground AI literacy, human-centred judgment, ethics, and the evaluation of generated outputs; these are best treated here as cross-cutting dimensions of TPACK rather than as a universally settled replacement model (Mikeladze et al., 2024). Miao and Cukurova's (2024) AI Competency Framework for Teachers identifies five dimensions: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning. These dimensions inform the proposed capacity building model below. The framework is a planning tool derived from literature, not evidence that teachers in the region have already been assessed or found deficient.

Applying TPACK to AI Capacity Building in TVE

Table 1 translates the framework into practical professional learning priorities. The AI-specific dimension is treated as an applied extension of TPACK: teachers consider AI literacy, human oversight, ethics, and the reliability of generated content alongside the established knowledge domains, rather than assuming that AI competence is a separate substitute for pedagogical and trade expertise.

TPACK component	**Application in TVE**	**Capacity-building activity / evidence**
Content knowledge (CK)	Accurate trade concepts, procedures, standards, and safety requirements.	Teachers check AI-generated technical explanations against manuals, curriculum documents, and recognized standards.
Pedagogical knowledge (PK)	Demonstration, guided practice, project work,	Teachers plan a lesson that combines explanation, learner

	troubleshooting, and competency assessment.	practice, feedback, and assessment.
Technological knowledge (TK)	Using accessible digital devices and suitable AI tools; understanding tool limits.	Teachers practise prompting, checking outputs, managing files, and using offline or low-bandwidth resources.
PCK	Choosing teaching methods suited to a particular trade concept or skill.	Teachers plan a demonstration and guided practice for a difficult concept or procedure.
TCK	Understanding how a digital/AI tool represents a trade process or technical system.	Teachers judge whether a simulation, diagram, or AI-generated fault scenario is technically accurate.
TPK	Using technology to support feedback, differentiation, formative assessment, and lesson preparation.	Teachers create and review quizzes, scenarios, or feedback prompts while retaining teacher judgment.
Integrated TPACK	Combining trade content, pedagogy, and technology for a specific learning outcome.	Teachers demonstrate a complete lesson/workshop plan and explain why AI is appropriate, what must remain hands-on, and how safety and accuracy will be checked.
AI-oriented cross-cutting competencies	Human-centred use, ethics, AI foundations, AI pedagogy, and professional learning, aligned with UNESCO (2024).	Teachers identify bias or errors, protect data, attribute use, provide non-AI alternatives, and reflect on impact.

Source: Adapted conceptually from Koh et al. (2015), Mishra and Koehler (2006), and Miao and Cukurova (2024).

Aim of the Study

The aim of this conceptual narrative review is to develop a literature-informed framework for professional capacity building for AI integration among Technical and Vocational Education (TVE) teachers in North-East Nigeria. It does not claim to establish the measured competence gaps of teachers in the region. Specifically, the paper seeks to:

1. Identify, from the literature and relevant policy documents, the professional competencies that may be required by Technical and Vocational Education teachers for effective and responsible AI integration.
2. Discuss context-sensitive strategies for strengthening professional capacity building and identify evidence gaps that future empirical needs assessments should address.

Concept of Artificial Intelligence in Technical and Vocational Education (TVE)

Artificial intelligence (AI) refers broadly to computer systems that perform tasks associated with human capabilities such as pattern recognition, language processing, prediction, and decision support (Huang, & Peissl, 2023). In TVE, the educational question is not whether AI is generally beneficial, but whether a particular tool is accurate, affordable, safe, accessible, and suitable for the learning objective.

Potential educational uses include generating lesson examples, explaining technical concepts, supporting formative quizzes, translating or simplifying learning materials, and helping teachers prepare troubleshooting scenarios. More specialised systems may support simulations, image-based fault identification, or equipment-condition analysis. Availability varies considerably; advanced industrial systems should not be assumed to exist in ordinary TVE workshops in North-East Nigeria.

Professional capacity building therefore means planned development of the knowledge, practical judgment, teaching skills, and ethical awareness required to select, test, adapt, and critically supervise AI-supported activities. Teachers should learn to verify AI outputs against manuals, standards, and expert knowledge; protect learners' data; disclose appropriate AI use; and ensure that technology supports, rather than replaces, demonstration and supervised hands-on practice.

The paper does not assume that AI automatically improves practical skills, employability, or training costs. Such outcomes depend on the quality of instruction, access to equipment, teacher competence, assessment design, and opportunities for repeated physical practice. They should be tested through future empirical studies in the region.

Trade-Specific Applications and Practical Limits

AI tools should be selected according to the trade task, available equipment, connectivity, cost, and the risk of error. The examples below are illustrative possibilities for teacher-led learning

activities, not claims that the named tools or advanced industrial systems are currently available in every North-East Nigerian institution.

TVE trade area	Potentially accessible classroom use	Industrial application to distinguish from routine teaching tools	Practical/safety boundary
Automotive technology	Use a general AI assistant to draft fault-finding scenarios, explain diagnostic trouble codes for teacher verification, or generate revision questions; use offline service manuals where available.	AI-assisted vehicle diagnostics, predictive maintenance, and connected-vehicle analytics.	Generated diagnosis must be checked with service information and diagnostic equipment; AI cannot replace physical inspection or safe workshop procedure.
Electrical/electronics	Generate circuit-theory explanations, component quizzes, and fault scenarios for teacher review; use available circuit simulators.	Machine-vision inspection, automated testing, and predictive maintenance in industry.	Do not use unverified AI instructions for live circuits; practical work requires isolation, test instruments, supervision, and safety rules.
Building construction	Create material-identification exercises, measurement problems, estimating examples, or visual checklists.	AI-supported site monitoring, design optimization, and computer-vision quality checks.	AI images or estimates may be wrong; students still need material handling, setting-out, measurement, and supervised site practice.
Woodwork/furniture	Prepare cutting-list examples, design prompts, and	Computer-aided manufacturing and automated	AI-generated dimensions require checking; machine

	quizzes; use CAD or drawing software where accessible.	cutting/nesting systems.	guarding, tool handling, and physical finishing cannot be replaced by a chatbot.
Agriculture	Generate crop-management case studies, pest-identification discussion prompts, and record-keeping templates; use downloaded resources where connectivity is poor.	Precision agriculture, sensor-based monitoring, and predictive crop analytics.	Image-based suggestions may misidentify pests or diseases; decisions should be verified with trusted local expertise and field observation.
Business/entrepreneurship	Draft business-plan exercises, customer-service scenarios, bookkeeping practice, and spreadsheet formulas for review.	Demand forecasting, automated customer analytics, and process automation.	Check calculations and protect customer data; students must develop independent judgment and financial literacy.
ICT/computer studies	Practise prompt evaluation, coding explanations, debugging discussions, digital safety, and data-literacy activities.	Machine learning deployment, intelligent automation, and large-scale data analytics.	Generated code may be insecure or incorrect; learners should test, document, and understand code rather than copy outputs.

Note. Examples are suggested teaching uses and should be adapted after local equipment, licensing, connectivity, curriculum, and safety checks. Industrial AI applications generally require infrastructure and specialist expertise beyond what a basic classroom AI assistant provides.

Professional Capacity Building for Artificial Intelligence Integration

For this review, professional capacity building is treated as a continuous cycle of baseline assessment, targeted training, mentored application, and evaluation. It should be connected to the trade being taught and to the realities of workshop delivery, including class size, equipment availability, electricity, connectivity, and safety requirements.

The literature derived competency areas include: (i) foundational AI and digital literacy; (ii) selecting and evaluating tools for trade-specific content; (iii) designing AI-supported demonstrations, scenarios, and formative assessment; (iv) interpreting AI-generated information and checking it against reliable technical sources; and (v) ethical, inclusive, privacy aware and safe use. These are proposed areas for local needs assessment, not measured gaps among North-East Nigerian TVE teachers.

Training should use authentic tasks: for example, preparing a lesson, checking an AI-generated explanation, developing a troubleshooting case, creating an offline worksheet, and evaluating whether a simulation accurately reflects the practical task. Competence should be demonstrated through lesson artefacts, observed teaching, and practical assessment rather than attendance certificates alone.

Professional Capacity Building Needs of Technical and Vocational Education (TVE) Teachers

The following needs framework is derived from the reviewed literature and Miao and Cukurova's (2024) AI Competency Framework for Teachers. It identifies competencies that a regional needs assessment could measure; it does not claim that all teachers require the same training or that the prevalence of each need is already known.

Priority areas include AI and digital literacy; trade-specific selection and verification of AI tools; AI-supported pedagogy and assessment; blended and offline lesson design; and responsible use, including privacy, bias, transparency, academic integrity, accessibility, and professional judgment. In practical subjects, teachers must also judge when AI use is inappropriate. A chatbot or simulation cannot replace the tactile, physical, and safety critical learning involved in wiring, welding, vehicle repair, construction, machine operation, or handling tools and materials. AI output must never override workshop rules, equipment manuals, instructor supervision, or established safety procedures.

Challenges and Conditions Affecting AI Integration in North-East Nigeria

Contextual conditions that may constrain AI integration include unreliable electricity, limited or costly internet access, shortages of suitable devices, software subscription costs, and limited technical support. These conditions vary between institutions, so they should be verified locally rather than treated as uniform across all six North-East states.

Insecurity and displacement have disrupted education in parts of the region, including through school closures and interrupted access to learning. Such evidence establishes a wider education-access challenge, but it does not by itself prove a specific AI-capacity gap among TVE teachers. Any program should therefore be flexible, locally planned, and able to continue through printed, downloadable, or offline materials when connectivity is unavailable.

There are also pedagogical and ethical risks. A systematic review by Chiu et al. (2023) identifies multiple challenges in AI in education, reinforcing the need to evaluate both implementation conditions and learning outcomes. AI systems can produce incorrect or fabricated technical advice, reproduce bias, expose personal information, encourage plagiarism, and lead learners to rely on generated answers without developing independent problem-solving skills. Automation may change some occupational tasks and skill demands, but the implications for local employment require careful investigation. Institutions should use approved tools where possible, minimize personal data, teach verification and attribution, and retain human responsibility for assessment and safety.

Strategies for Enhancing Professional Capacity Building for Artificial Intelligence Integration

A practical model for North-East Nigerian TVE institutions should follow a staged cycle: (i) assess needs and readiness; (ii) provide foundational and trade-specific training; (iii) support classroom and workshop application through mentoring; and (iv) evaluate competence and revise the program. This sequence links capacity building to observed teaching practice rather than assuming that a one-off workshop produces sustained change.

At the first stage, departments should assess teachers' AI awareness, digital skills, previous training, device access, connectivity, trade area, and confidence in evaluating AI outputs. Training can then combine a short face-to-face workshop with training-of-trainers and cascade delivery. In low-connectivity settings, use downloadable resources, locally stored examples, printed guides, offline-capable applications, and shared devices; online tools should be optional supplements rather than the only route to participation.

Training should be practice-based and trade-specific. Teachers should develop a lesson or workshop activity, test AI-generated content for accuracy, prepare a non-AI alternative, and demonstrate how learners will be assessed. Pairing less experienced teachers with trained mentors,

peer observation, and follow-up clinics can support implementation. Industry partners can contribute current task examples and safety expectations, but institutional staff must review materials for curriculum relevance and local feasibility.

Stakeholder responsibilities should be explicit: institutional leaders provide time, local coordination, safeguarding, and access to equipment; TVE departments identify trade-specific priorities and review lesson materials; teacher educators and trained facilitators deliver professional learning; industry partners advise on current occupational practices; and relevant agencies, including NBTE and NCCE within their respective mandates, support alignment with applicable standards and teacher-development priorities.

Evaluation should use baseline and follow-up indicators: changes in teachers' AI and digital literacy; quality and accuracy of lesson materials; observed use of appropriate pedagogy; ability to identify errors, bias, and privacy risks; learner task performance where measurable; availability and use of offline resources; and evidence of continued peer mentoring. Funding can be assembled from institutional professional-development allocations, relevant government education and TVET programs, competitive research or innovation grants, and transparent industry partnerships. Funding claims and eligibility should be checked against current program rules.

Conclusion

This conceptual narrative review proposes a literature-informed approach to professional capacity building for AI integration in TVE. Its central argument is that teachers need more than access to AI tools: they need trade-specific judgment, pedagogical design skills, the ability to verify outputs, and an understanding of ethical and safety limits.

TPACK, complemented by Miao and Cukurova's (2024) AI competency framework for teachers, provides a structure for connecting technology with trade content and practical pedagogy. A staged cycle of needs assessment, hands-on training, mentoring, and evaluation offers a context-sensitive way to develop these competencies while accommodating low-connectivity environments and unequal institutional resources.

Because this paper is a narrative review rather than an empirical needs assessment, it cannot establish the actual prevalence or ranking of competency gaps among TVE teachers in North-East

Nigeria, nor can it conclude that AI has already improved student outcomes in the region. These questions require institution-level research.

Recommendations

The following recommendations are directly linked to the analysis and should be adapted to each institution's readiness and trade areas:

1. Conduct a baseline needs and readiness assessment before selecting training content. Measure teachers' existing AI knowledge, digital access, previous professional development, trade specialization, and concerns about accuracy, privacy, and safety.
2. Deliver a staged, practice-based professional development program using training-of-trainers, cascade workshops, mentoring, peer observation, and follow-up clinics. Require participants to produce and demonstrate a trade-specific lesson or workshop activity, not merely attend a seminar.

3. Map training to TPACK and Miao and Cukurova's (2024) framework. Include foundational AI literacy, trade-content verification, pedagogical application, human-centred practice, ethics, and professional learning. Use examples from automotive, electrical/electronics, construction, woodwork, agriculture, business, and ICT.

4. Provide realistic low-connectivity options: downloadable or locally stored materials, printed guides, shared devices, reliable power where feasible, and offline alternatives. Do not make paid subscriptions or continuous internet access a condition for participation.

5. Establish reviewed industry-institution partnerships for authentic task examples, current technical standards, mentorship, and equipment exposure. Require teachers to check all AI-generated technical content against trusted manuals and ensure that simulations never replace essential supervised hands-on practice or safety procedures.

6. Assign institutional leaders, departments, facilitators, industry partners, and relevant regulatory agencies clear responsibilities, and identify transparent funding sources through institutional budgets, applicable public programs, grants, or partnerships.

7. Evaluate outcomes using baseline and follow-up evidence, including teacher competence, quality of teaching resources, observed classroom/workshop practice, ethical and safety judgment, and feasible learner-performance indicators. Use results to revise the program and report limitations openly.

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