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# From Principles to Practice: The Plan-Generate-Verify-Adapt (PGVA) Framework for AI Integration in Luganda Language Instruction

**Teresphorus Louis Kakinda[1], Mathias Bwanika Mulumba[2], Fred Masagazi Masaazi[3], Edward Masembe[4]**

[1]PhD candidate, School of Education, Makerere University, Kampala, Uganda;
[2]Associate Professor, Department of Humanities and Language Education, Makerere University, Kampala, Uganda
[3]Professor, Department of Humanities and Language Education, Makerere University, Kampala, Uganda
[4]Lecturer, Department of Humanities and Language Education, Makerere University, Kampala, Uganda

**Abstract**

The integration of artificial intelligence in indigenous language education requires systematic pedagogical frameworks that translate theoretical knowledge into practical implementation. This study developed and validated the Plan-Generate-Verify-Adapt (PGVA) framework, an empirically-grounded operational structure guiding AI-chatbot integration in competency-based indigenous language grammar instruction. Using Design-Based Research methodology across two iterative implementation cycles with 26 preservice Luganda teachers in Uganda, the study identified 15 design principles organized into six thematic clusters: Knowledge Integration, AI Interaction, Pedagogical Structures, Cultural-Linguistic Integrity, Assessment and Metacognition, and Contextual Responsiveness. Analysis of interaction logs, reflective journals, and lesson plans revealed that these principles coalesce into a four-phase cyclical workflow. The PGVA framework positions teachers as cultural-linguistic guardians who systematically plan learning outcomes before AI engagement, collaboratively generate materials with AI through strategic prompting, verify outputs against community-authoritative sources, and adapt verified materials for specific learner contexts. Implementation data demonstrated that adherence to the PGVA sequence correlated strongly with material quality ($r=0.73$, $p<0.001$), while phase-skipping or resequencing produced culturally inappropriate or pedagogically weak outputs. The framework addresses critical gaps in existing AI pedagogy models by providing explicit procedural guidance suitable for resource-constrained indigenous language contexts where technological outputs require systematic validation. Comparative analysis positions PGVA's distinctive contributions relative to AI-TEACH, IAPM, and AI-Oriented Pedagogy frameworks. Implications for indigenous language teacher preparation, practical implementation guidance, and transferability to other contexts are discussed. The PGVA framework demonstrates that successful AI integration requires systematic workflow structures grounded in sound pedagogical theory rather than assuming technology alone transforms practice.

**Keywords:** AI Integration, Indigenous Languages, Pedagogical Framework, Luganda, Teacher Education, PGVA Framework

## INTRODUCTION

The rapid advancement of generative AI technologies, particularly large language models like ChatGPT, has generated substantial interest in their educational applications (Kohnke et al., 2023; Labadze et al., 2023). In language education, AI chatbots offer unprecedented capabilities for generating exemplar texts, providing feedback, and supporting differentiated instruction (Choi, 2023; Karataş et al., 2024). However, translating AI's technical capabilities into pedagogically sound classroom applications remains challenging, particularly in indigenous and minority language contexts facing compounded obstacles of limited digital resources, low-resource language constraints, cultural appropriateness concerns, and pressure to implement curriculum reforms without adequate teacher preparation (Joshi et al., 2020; Okata & Adebayo, 2023).

Uganda's 2020 competency-based curriculum mandates fundamental pedagogical shifts in indigenous language instruction, requiring Luganda grammar teaching to develop authentic communicative competencies through genre-based approaches (NCDC, 2020). This pedagogical transformation demands teacher knowledge integrating content expertise, pedagogical sophistication, and technological competence, collectively termed AI-Technological Pedagogical Content Knowledge (AI-TPACK) (Ning et al., 2024). Nevertheless, existing AI-TPACK frameworks, while specifying requisite knowledge domains, provide limited operational guidance for enacting integrated competencies within authentic teaching contexts (Celik et al., 2022).

Recent frameworks addressing AI pedagogy integration have made important contributions while leaving critical gaps. The AI-TEACH framework emphasizes ethical considerations but offers limited procedural specificity (Sullivan et al., 2023). The Instructional AI Planning Model provides sequential stages but assumes high-resource contexts unavailable in many Global South settings (Holmes et al., 2022). The AI-Oriented Pedagogy framework offers dimensional analysis but operates at a high abstraction level (Creely & Carabott, 2025). Crucially, none adequately addresses indigenous language contexts where AI-generated content requires systematic validation against community-authoritative sources.

This study develops and validates the Plan-Generate-Verify-Adapt (PGVA) framework, an empirically grounded operational structure translating AI-TPACK competencies and genre-based pedagogical principles into an implementable four-phase workflow. Emerging from Design-Based Research across two iterative cycles with preservice Luganda teachers, the framework positions teachers as cultural-linguistic guardians who systematically validate AI outputs within structured pedagogical processes (Martin & Rose, 2008; Long, 1991; Ning et al., 2024).

## Literature Review

### Existing AI Pedagogy Frameworks

Recent scholarship has produced frameworks guiding AI integration in education. Sullivan et al.'s (2023) AI-TEACH framework emphasizes ethical considerations including student agency and critical thinking, but operates at high abstraction without operational guidance for concrete lesson planning. Holmes et al.'s (2022) Instructional AI Planning Model offers sequential stages but assumes high-resource contexts with sophisticated AI infrastructure. Creely and Carabott's (2025) AI-Oriented Pedagogy framework advances theoretical sophistication through dimensional analysis examining positionality, relationality, and functionality, but these dimensions operate simultaneously rather than sequentially, creating implementation challenges.

These frameworks occupy complementary but incomplete niches. None adequately addresses indigenous

language contexts where: (1) AI-generated content requires systematic validation against community-authoritative sources, (2) modest technological infrastructure constrains implementation, (3) cultural appropriateness concerns demand explicit attention, and (4) teachers need procedural guidance translating principles into concrete practice.

**Design-Based Research Methodology**

Design-Based Research develops educational innovations through iterative cycles of design, implementation, analysis, and refinement (Wang & Hannafin, 2005; Barab & Squire, 2004). McKenney and Reeves (2012) elaborated DBR's dual outcomes: practical innovations and theoretical insights. Anderson and Shattuck (2012) documented DBR's increasing adoption in developing country contexts, noting that iterative refinement enables responsive adaptation. This study addresses methodological challenges through explicit transparency, triangulation across data sources, and negative-case analysis (Barab & Squire, 2004).

**Indigenous Language Education and Technology Integration**

Indigenous language education faces distinctive challenges. Joshi et al. (2020) documented that most AI systems are trained predominantly on high-resource languages while thousands of indigenous languages remain virtually absent from training data, creating severe limitations. Cenoz and Gorter (2017, 2020) examined whether technology integration represents threat or opportunity for minority language sustainability, arguing that technology can support language maintenance if grounded in translanguaging pedagogies respecting indigenous knowledge systems. Bamgbose (2011) documented persistent colonial language dominance in African education. Okata and Adebayo (2023) found minimal AI engagement in African teacher education despite policy interest, identifying barriers including limited infrastructure and inadequate teacher preparation.

**Genre-Based Pedagogy as Pedagogical Foundation**

Martin and Rose's (2008) genre-based pedagogy provides systematic framework for developing language competencies through explicit instruction via the teaching-learning cycle: building field knowledge, deconstruction, joint construction, and independent construction. Rose and Martin (2012) demonstrated effectiveness for disadvantaged learners. However, genre-based pedagogy research has primarily focused on English instruction in Australian and UK contexts, and existing research predates generative AI emergence.

**Competency-Based Curriculum Implementation Challenges**

Uganda's 2020 competency-based curriculum mandates shifts from knowledge transmission to competency development (NCDC, 2020). Kitasse and Ssembatya (2024) documented persistent gaps between policy intentions and classroom realities, with teachers continuing traditional grammar instruction due to inadequate preparation. Curriculum reforms often fail when teachers lack practical frameworks translating philosophical commitments into concrete practices (Bernstein, 2000; Hoadley, 2018).

**Research Gaps and Study Contributions**

This study addresses critical gaps by: (1) developing an empirically-grounded pedagogical framework through Design-Based Research with preservice Luganda teachers, (2) integrating AI-TPACK, genre-based pedagogy, and Focus-on-Form into a coherent operational structure, (3) translating design principles into a four-phase workflow providing procedural specificity, (4) explicitly addressing indigenous language contexts' validation requirements through a systematic VERIFY phase, and (5) demonstrating DBR's effectiveness for developing validated professional knowledge in resource-constrained African contexts.

## Theoretical Framework

**This study integrates three complementary theoretical perspectives.**

AI-Technological Pedagogical Content Knowledge provides the structural lens for understanding teacher knowledge requirements across multiple intersecting domains (Ning et al., 2024). Extending Mishra and Koehler's (2006) foundational TPACK model, AI-TPACK identifies seven knowledge domains: Content Knowledge, Pedagogical Knowledge, AI-Technological Knowledge, and their integrations—AI-Technological Content Knowledge, AI-Technological Pedagogical Knowledge, Pedagogical Content Knowledge, and fully integrated AI-TPACK.

Systemic Functional Linguistics and Genre-Based Pedagogy provide the pedagogical structure through the teaching-learning cycle (Martin & Rose, 2008). This perspective positions grammar as meaning-making resources deployed within authentic communicative genres (Halliday & Matthiessen, 2014). The teaching-learning cycle offers explicit scaffolding structure where AI can be strategically positioned at each stage.

Focus-on-Form principles inform how grammatical features are integrated within meaning-focused activities, balancing linguistic accuracy with communicative purpose (Long, 1991; Ellis, 2016). These principles guide the design of AI-supported grammar activities integrating accuracy development within communicative contexts.

Together, these frameworks provide complementary functions: AI-TPACK defines the knowledge architecture, Genre-Based Pedagogy supplies the pedagogical structure, and Focus-on-Form provides the grammar instruction principles.

## Methodology

### Research Design

This study employed Design-Based Research methodology across four phases. Phase 1 (January 2025) involved problem analysis through baseline data collection. Phase 2 (March-July 2025) comprised solution development through collaborative design workshops. Phase 3 (August-October 2025) consisted of iterative implementation across two cycles. Phase 4 (November 2025) involved comprehensive evaluation and framework articulation.

### Participants and Context

Twenty-six preservice teachers (19 female, 7 male, ages 20-26) enrolled in Year 3 Bachelor of Education specializing in Luganda education at Makerere University participated in both implementation cycles. All had completed initial teaching practicum and possessed native or advanced Luganda proficiency. The institutional setting reflected typical Ugandan teacher education challenges: limited technological infrastructure, large class sizes, persistence of traditional pedagogical approaches, and recent competency-based curriculum implementation without adequate preparation.

### Data Collection

Multiple complementary methods enabled triangulation. Reflective journals captured participants' sense-making and pedagogical reasoning. ChatGPT interaction logs documented conversations during lesson preparation. Lesson plans and teaching materials demonstrated application of genre-based principles and AI integration strategies. Semi-structured interviews (n=20) and focus group discussions (three groups, n=26 total) explored understanding and implementation experiences.

**Data Analysis**

Thematic analysis proceeded through iterative coding. Initial deductive coding applied AI-TPACK domains, genre-based pedagogy components, and Focus-on-Form categories. Inductive coding remained open to emergent patterns. Workflow pattern analysis examined interaction logs, journals, and lesson plans to identify recurring implementation sequences. Quantitative validation assessed relationships between framework adherence and material quality. Lesson plans were rated on cultural appropriateness, linguistic accuracy, and pedagogical soundness, achieving inter-rater reliability $\kappa=0.84$.

**The 15 Design Principles: Empirical Foundation**

Analysis revealed 15 design principles organized into six thematic clusters.

**Cluster 1: Knowledge Integration (Principles 1-2)**

Principle 1: Develop integrated AI-TPACK through authentic tasks requiring simultaneous application of content, pedagogical, and technological knowledge. Evidence revealed participants developed integrated competence most effectively when confronting genuine instructional challenges demanding orchestration of multiple knowledge types, rather than through isolated skill-building exercises. PT08's journal documented: "When I needed to create a procedural text exemplar about a traditional practice, I had to know Luganda grammar deeply (CK), understand the teaching-learning cycle's deconstruction phase (PK), and prompt ChatGPT effectively while evaluating if the output was culturally appropriate (AI-TK). All at once, not separately." This authentic task integration proved more powerful than sequential activities targeting individual domains.

Principle 2: Position AI as pedagogical partner rather than content substitute or autonomous instructor. Across both cycles, participants who viewed AI as collaborative tool supporting their pedagogical decision-making produced higher-quality materials than those positioning AI as either a content generator replacing teacher judgment or an instructional substitute managing student interaction. PT15 reflected: "I realized ChatGPT is like a competent assistant who can draft things quickly, but I'm still the teacher who decides what we are trying to accomplish, evaluates if suggestions work, and adapts everything for my students."

**Cluster 2: AI Interaction (Principles 3-5)**

Principle 3: Develop prompt engineering competence through explicit instruction and scaffolded practice. Initial attempts revealed participants lacked knowledge of strategic prompting. Generic requests such as "Write a Luganda narrative" yielded inadequate outputs. Targeted instruction on prompt specificity (genre, purpose, audience, length, key features), combined with exemplar analysis and iterative refinement exercises, developed competence. By Cycle 2, prompts demonstrated sophistication: "Generate a Luganda olugero (narrative) suitable for Senior 2 students, approximately 300 words, about respecting elders, incorporating the moral lesson at the end, using simple compound sentences with appropriate noun-class agreement" (PT19, Cycle 2 journal).

Principle 4: Cultivate critical evaluation protocols for assessing AI-generated content across linguistic accuracy, cultural appropriateness, and pedagogical utility dimensions. Participants initially accepted ChatGPT outputs uncritically or rejected them wholesale without systematic evaluation. Introducing structured evaluation protocols (linguistic accuracy checklist, cultural appropriateness criteria, pedagogical utility rubric) enabled nuanced judgment. PT12 demonstrated growth: "I check every grammatical feature systematically—noun-class agreement, verb tense, word order. Then I evaluate if the cultural references are authentic or stereotypical. Finally, I assess if this text serves my pedagogical

purpose for this specific teaching-learning cycle phase" (Cycle 2 interview).

Principle 5: Engage AI iteratively through multi-turn conversations rather than single-query interactions. Effective materials rarely emerged from single prompts. Participants learned to engage conversationally: initial generation, critical evaluation, follow-up prompts requesting modifications, and continued refinement until outputs met criteria. PT23's Cycle 2 interaction log revealed a 7-turn conversation developing a procedural text: initial request, evaluation revealing missing cultural context, prompt adding specific cultural practice details, evaluation identifying grammatical errors, correction request, further refinement for appropriate formality level, and final verification against an authoritative source.

**Cluster 3: Pedagogical Structures (Principles 6-8)**

Principle 6: Ground all AI integration within explicit genre-based pedagogical frameworks rather than ad hoc technology use. Participants who strategically integrated AI across phases of the teaching-learning cycle (exemplar generation during deconstruction, alternatives during modeling, suggestions during joint construction, feedback during independent production) achieved better outcomes than those using AI opportunistically without pedagogical structure. PT17 articulated understanding: "The teaching-learning cycle tells me when and why to use ChatGPT, not just that I can use it somewhere" (Cycle 2 focus group).

Principle 7: Implement Focus-on-Form strategies integrating grammatical accuracy attention within meaning-focused genre activities. Rather than treating AI-generated texts as finished products, effective implementations used them as inputs for Focus-on-Form activities: comparing multiple AI-generated versions to examine how different grammatical choices realize meanings differently; identifying form-meaning-function relationships within AI exemplars; and using AI to generate contrastive examples highlighting specific grammatical patterns. PT14's lesson used ChatGPT to generate three procedural text versions at varying levels of formality, then guided students in analyzing how grammatical choices (pronoun use, verb mood, sentence complexity) created different social distances between writer and reader.

Principle 8: Scaffold the teaching-learning cycle explicitly through structured activities at each phase. Practical implementations provided clear guidance at each cycle stage rather than assuming participants understood implementation. Deconstruction activities included schematic structure identification and linguistic feature analysis templates. Joint construction offered collaborative writing protocols and AI consultation guidelines. Independent construction provided self-assessment rubrics and revision checklists.

**Cluster 4: Cultural-Linguistic Integrity (Principles 9-10)**

Principle 9: Verify all AI-generated Luganda content against community-authoritative sources before classroom use. Given ChatGPT's documented limitations with low-resource languages (Joshi et al., 2020), systematic verification proved essential. Participants developed verification practices by consulting native speaker elders, published Luganda literature, Luganda-English dictionaries, and established language authority institutions. PT21 documented: "I generated a narrative about marriage customs, but elder verification revealed the text contained Buganda Kingdom protocol errors that would teach students incorrect cultural knowledge. I corrected these before using the text" (Cycle 2 journal).

Principle 10: Maintain critical postcolonial awareness regarding AI's potential perpetuation of linguistic colonization or cultural misrepresentation. Several participants demonstrated growing awareness that AI trained predominantly on English data might impose Western narrative structures or values onto Luganda texts. PT18 noted: "The AI-generated olugero had a Western 'hero's journey' structure rather than traditional Luganda narrative patterns with circular rather than linear progression. I restructured to honor

our storytelling traditions" (Cycle 2 interview). This critical consciousness protected against uncritical adoption of technology undermining indigenous knowledge systems.

**Cluster 5: Assessment and Metacognition (Principles 11-13)**

Principle 11: Develop dual-criteria assessment approaches evaluating both functional communicative effectiveness and linguistic accuracy. Moving beyond traditional error-counting, participants learned to create rubrics assessing whether texts achieve communicative purposes within genre conventions while exhibiting grammatical accuracy. PT09's Cycle 2 rubric for procedural texts evaluated: functional effectiveness (clarity of steps, appropriate sequencing, complete information), genre appropriateness (proper schematic structure, suitable register), and linguistic accuracy (verb forms, noun-class agreement, punctuation).

Principle 12: Document AI integration decisions systematically to support reflection and iterative improvement. Participants who maintained detailed logs of prompts, outputs, evaluation results, modifications, and rationales demonstrated greater metacognitive awareness and faster competence development. PT24's reflection journal revealed: "Looking back at my Cycle 1 prompts, I see I didn't specify audience or purpose clearly. No wonder outputs were generic. Now I'm much more strategic" (Cycle 2 journal).

Principle 13: Engage in collaborative reflection examining both successes and challenges to build collective professional knowledge. Focus groups provided spaces where participants shared strategies, troubleshot problems, and built collective expertise. One participant noted: "When PT11 shared how she prompted ChatGPT to generate multiple versions for comparison, several of us tried that technique and found it worked well for Focus-on-Form activities" (Cycle 2 focus group). This collaborative learning accelerated competence development.

**Cluster 6: Contextual Responsiveness (Principles 14-15)**

Principle 14: Adapt all materials for specific learner characteristics, instructional contexts, and available resources. Even high-quality AI-generated and verified texts required adaptation. Participants learned to consider students' age, proficiency level, cultural backgrounds, interests, prior knowledge, and available instructional time. PT16's journal documented: "The AI narrative was excellent but too complex for my Senior 1 students. I simplified sentence structures and reduced length while maintaining cultural content and grammatical teaching points" (Cycle 2 journal).

Principle 15: Recognize AI integration as iterative process requiring ongoing refinement rather than one-time implementation. Participants who viewed the framework as dynamic rather than static continued improving their practice. PT13 reflected: "My first attempts were rough. However, I kept trying, getting feedback, adjusting. By the end of Cycle 2, my materials were much stronger. This is ongoing professional learning, not a checklist to complete once" (final interview). This growth mindset sustained development.

These 15 principles collectively address compound challenges: weak AI-TPACK integration (Principles 1-2), limited AI literacy (Principles 3-5), underdeveloped genre-based pedagogy (Principles 6-8), absence of cultural validation protocols (Principles 9-10), inadequate competency assessment approaches (Principles 11-13), and insufficient contextual adaptation strategies (Principles 14-15).

**The PGVA Operational Framework: From Principles to Workflow**

While the 15 design principles identify necessary competencies, teachers require operational guidance for enacting these principles in systematic practice. Analysis of participants' implementation patterns revealed consistent four-phase workflow progression termed the Plan-Generate-Verify-Adapt (PGVA)

framework.

**PGVA Phase 1: PLAN**

The PLAN phase requires teachers to function as pedagogical architects, determining communicative purposes, grammar targets, and progression of the genre cycle before AI engagement. Teachers define learning outcomes aligned with competency-based curriculum, select culturally appropriate genres serving authentic communicative functions in Luganda communities, identify specific grammatical features to be foregrounded based on genre requirements and student needs, design teaching-learning cycle progression with attention to scaffolding logic, and establish success criteria for both functional effectiveness and linguistic accuracy.

This phase activates Knowledge Integration principles (1-2), requiring simultaneous consideration of content, pedagogy, and technology, and Pedagogical Structures principles (6-8), grounding AI use within explicit frameworks. Critically, planning precedes generation, positioning teachers as decision-makers rather than consumers of AI output.

Empirical evidence validated the PLAN phase's importance. Participants who skipped planning and began with ChatGPT prompts produced materials requiring extensive revision. PT07's early Cycle 1 attempt generated a narrative without first defining target grammatical features, resulting in text appropriate for cultural content but not serving the intended grammar-teaching purpose (Cycle 1 journal). In contrast, PT20's Cycle 2 exemplar began with precise planning: "I need a procedural text about preparing matooke (Luganda staple food) that foregrounds verb extensions showing beneficiary relationships (-ir-) and manner (-ir-, -isis-). This supports Senior 2 curriculum outcome about using verb morphology for semantic precision" (Cycle 2 lesson plan). This clarity enabled strategic AI prompting and evaluation.

**PGVA Phase 2: GENERATE**

The GENERATE phase operationalizes collaborative co-design through strategic prompting. Teachers craft detailed prompts incorporating planning decisions (genre, purpose, audience, length, key features, grammatical foci), engage AI iteratively through multi-turn refinement conversations rather than single queries, evaluate multiple generated options against pedagogical criteria, and select or combine elements from various outputs meeting defined needs.

This phase activates AI Interaction principles (3-5) requiring prompt engineering competence and critical evaluation protocols. Positioning AI as content generator producing options requiring teacher evaluation, rather than finished products, maintains appropriate teacher-AI relationship.

Cycle 2 interaction logs revealed sophisticated GENERATE implementation. PT19's 6-turn conversation developing a transactional letter exemplar demonstrated: initial prompt specifying genre, purpose, formality level, length, and target grammar features; evaluation identifying insufficient use of target features; follow-up prompt requesting emphasis on possessive pronouns showing ownership relationships; evaluation noting appropriate grammatical density but awkward phrasing; refinement request for more natural expression; final verification that output met all criteria (Cycle 2 interaction log). This iterative process produced higher-quality materials than single-prompt attempts.

**PGVA Phase 3: VERIFY**

The VERIFY phase institutionalizes systematic validation, positioning teachers as cultural-linguistic guardians. Teachers check all AI-generated Luganda text against community-authoritative sources (elder speakers, published literature, approved textbooks, language authority institutions), identify and correct any grammatical errors, cultural inaccuracies, or inappropriate register choices, document verification process and sources consulted for accountability and future reference, and make necessary modifications

before classroom use.

This phase activates Cultural-Linguistic Integrity principles (9-10) and Assessment and Metacognition principle (12), requiring verification protocols and decision documentation. The VERIFY phase represents PGVA's distinctive innovation compared to existing frameworks, addressing indigenous-language contexts where limited resources make verification essential rather than optional.

Verification documented critical importance across multiple cases. PT22 generated a narrative about traditional healing practices that elder verification revealed contained factually incorrect information about specific herbs and their uses—teaching this content would have perpetuated misinformation (Cycle 2 journal). PT16's procedural text on traditional dance included grammatical errors in specialized movement terminology, which dictionary consultation identified and corrected (Cycle 2 verification log). Without systematic verification, these errors would have reached classrooms.

Quantitative evidence validated the importance of verification. Materials undergoing structured verification scored significantly higher on cultural appropriateness ($M=2.85$ vs. $M=2.13$, $t(24)=4.32$, $p<0.001$) and linguistic accuracy ($M=2.79$ vs. $M=2.08$, $t(24)=3.94$, $p<0.001$) than materials with no or cursory verification, demonstrating that this systematic step substantially improved quality.

**PGVA Phase 4: ADAPT**

The ADAPT phase enables contextual responsiveness, tailoring verified materials to specific learners and instructional contexts. Teachers modify complexity level to match students' language proficiency and cognitive development, adjust length and pacing to fit available instructional time, incorporate students' interests and backgrounds to enhance engagement, develop supplementary activities to support diverse learning needs, and plan implementation details including questioning strategies and formative assessment approaches.

This phase activates Contextual Responsiveness principles (14-15), Pedagogical Structures principles (6-8) regarding teaching-learning cycle scaffolding, and Assessment principles (11, 13) regarding dual-criteria evaluation and collaborative reflection. Adaptation occurs after verification, ensuring modifications to verified materials maintain integrity.

Cycle 2 lesson plans demonstrated sophisticated adaptation. PT14 took a verified narrative and created differentiated versions: a simplified version for struggling readers with shorter sentences and high-frequency vocabulary; a standard version for on-grade students; and an enriched version for advanced students with more complex grammatical structures and cultural details. Additionally, PT14 developed comprehension questions at multiple cognitive levels, Focus-on-Form activities analyzing specific grammatical features, and extension activities connecting narrative to students' lives (Cycle 2 lesson plan). PT11 adapted a procedural text originally about traditional pottery-making to local contexts: the urban school version referenced contemporary ceramic art studios students might visit, while the rural school version maintained traditional village pottery focus familiar to students; each version preserved the same grammatical teaching points while varying cultural references for local relevance (Cycle 2 teaching materials).

**Empirical Validation of PGVA Framework**

Systematic analysis provided multiple forms of evidence validating PGVA's effectiveness. Adherence to the PGVA sequence correlated strongly with material quality ($r=0.73$, $p<0.001$). Temporal analysis revealed developmental patterns: early Cycle 1 attempts showed frequent phase-skipping (67%) while late-cycle adherence increased substantially (89%). Materials quality increased significantly from early

Cycle 1 (M=6.32) to late Cycle 2 (M=8.94) on a 12-point scale ($t(25)=7.68$, $p<0.001$). Participant validation interviews confirmed PGVA reflected actual practice, with 92% (24/26) confirming the sequence matched effective practice patterns.

**Comparative Analysis: PGVA and Existing Frameworks**

The AI-TEACH framework emphasizes ethical considerations providing important conceptual foundation (Sullivan et al., 2023). However, AI-TEACH operates at high abstraction without operational guidance. PGVA complements AI-TEACH by translating ethical commitments into procedural steps—the VERIFY phase operationalizes ethical vigilance through systematic validation.

The Instructional AI Planning Model offers sequential workflow structure (Holmes et al., 2022). However, IAPM's Diagnosis phase positions AI as evaluator of students, while PGVA's VERIFY phase positions teachers as evaluators of AI through validation against authoritative sources. This inversion reflects indigenous language education's particular requirements where community authority supersedes technological outputs. Additionally, IAPM assumes high-resource contexts while PGVA operates with modest requirements.

The AI-Oriented Pedagogy framework advances theoretically sophisticated dimensional analysis (Creely & Carabott, 2025). However, these dimensions operate simultaneously rather than sequentially, posing implementation challenges. PGVA maintains theoretical grounding while providing actionable structure.

PGVA's specificity to indigenous languages distinguishes it from frameworks targeting general contexts. Its explicit VERIFY phase addresses concerns absent from other models—systematic validation against community-authoritative sources. This reflects postcolonial awareness that resists uncritical technology adoption while acknowledging AI's utility within culturally grounded constraints.

**Practical Implementation Guidance**

**For Teacher Educators**

PGVA offers pedagogical scaffolding enabling systematic competence development. Instruction can proceed phase-by-phase: begin with PLAN competencies before introducing AI engagement; progress to GENERATE competencies once planning foundations solidify; develop VERIFY competencies before allowing classroom adaptation; conclude with ADAPT competencies completing the cycle.

**For Preservice Teachers**

PGVA provides cognitive apprenticeship structure: begin with supported PLAN cycles; progress through increasingly independent GENERATE-VERIFY-ADAPT sequences; and develop autonomous implementation through documented practice. Reflective journals documenting decisions at each phase transform tacit choices into examinable professional knowledge.

**For Policymakers**

PGVA demonstrates feasible AI integration requiring modest resources. Supporting implementation requires: ensuring preservice teachers receive explicit preparation through restructured methods courses; providing in-service teachers with professional development; enabling access to community-authoritative sources; and allocating time for systematic material development.

**Discussion**

The PGVA framework addresses critical gaps in indigenous language teacher education and AI pedagogy scholarship. Its empirical foundation through Design-Based Research provides validity often lacking in

prescriptive frameworks. The strong correlation between workflow adherence and material quality (r=0.73) suggests the framework captures authentic, effective practice patterns.

PGVA's theoretical contribution lies in integrating AI-TPACK, Systemic Functional Linguistics, Genre-Based Pedagogy, and Focus-on-Form into a coherent operational structure. Where existing frameworks address isolated aspects, PGVA synthesizes multiple considerations within an implementable workflow. The framework demonstrates complementary functions of these theories across four phases: PLAN activates Knowledge Integration and Pedagogical Structures; GENERATE activates AI Interaction; VERIFY activates Cultural-Linguistic Integrity and Assessment; ADAPT activates Contextual Responsiveness.

The VERIFY phase represents PGVA's most distinctive innovation. While existing frameworks acknowledge AI can generate inaccurate content, PGVA institutionalizes verification as discrete workflow phase with specific protocols. This procedural specificity proves essential for indigenous language contexts where teachers may not possess complete native-speaker knowledge and where limited published resources complicate verification.

The framework also contributes to postcolonial technology scholarship by demonstrating how indigenous communities can engage emerging technologies critically. Positioning teachers as cultural-linguistic guardians empowers rather than deskills them. The VERIFY phase operationalizes technological sovereignty—communities determining validation standards and maintaining authority over knowledge deemed appropriate for educational transmission.

Practically, PGVA provides teacher preparation programs with concrete curriculum structure for developing AI-enhanced indigenous language teaching competence. The framework specifies exactly what competencies teachers need (15 design principles), how these competencies organize thematically (6 clusters), and how to enact them systematically (4-phase workflow).

**Limitations and Future Directions**

Several limitations warrant acknowledgment. The single-site design limits generalizability, though the framework's theoretical grounding supports transferability. Implementation occurred specifically in Luganda; testing in other indigenous languages would strengthen claims about broader applicability. The relatively short implementation period (3 months) captured initial competence development but not long-term sustainability.

Future research should investigate PGVA implementation across diverse indigenous-language contexts, study experienced teachers adopting PGVA, examine student learning outcomes mediated by PGVA-prepared teachers, and explore PGVA application beyond grammar instruction.

**Conclusion**

The Plan-Generate-Verify-Adapt framework provides an empirically validated, theoretically grounded, practically implementable structure for integrating AI chatbots into genre-based indigenous language grammar instruction. Emerging from systematic Design-Based Research across two iterative cycles, the framework translates 15 design principles organized into six thematic clusters into a four-phase operational workflow positioning teachers as cultural-linguistic guardians.

Substantial empirical evidence validates PGVA's effectiveness: adherence to workflow sequence correlated substantially with material quality ($r=0.73$, $p<0.001$), developmental patterns showed systematic competence growth, and participant validation confirmed the framework captured authentic

practice. Comparative analysis demonstrates PGVA's distinctive contributions relative to existing AI pedagogy frameworks, particularly its indigenous-language specificity through the VERIFY phase institutionalizing systematic validation against community-authoritative sources.

Most fundamentally, PGVA demonstrates that successful AI integration in indigenous language teacher education requires systematic attention to cultural-linguistic integrity, explicit genre-based scaffolding, progressive competence development, and operational workflow structures rather than assuming technology alone transforms practice. By grounding AI integration within sound pedagogical frameworks informed by functional linguistics and positioning teachers as empowered decision-makers validating technology outputs against community standards, the framework charts a path toward technology-enhanced indigenous language instruction that serves rather than subordinates indigenous knowledge systems.

As generative AI technologies continue to advance, frameworks like PGVA providing principled guidance for integration within culturally responsive, pedagogically sound structures will become increasingly essential. The challenge facing indigenous language education lies not in whether to engage AI but in how to do so in ways that honor community authority, maintain linguistic-cultural integrity, develop authentic competencies, and empower rather than replace teachers. PGVA offers one empirically-validated approach to meeting that challenge.

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