

Designing an Adaptive Curriculum Framework for Nonformal Education in the Era of Artificial Intelligence

A Digital Andragogy Approach

¹Rofik Jalal Rosyanafi*, ¹Gunarti Dwi Lestari, ¹Rivo Nugroho, ¹Kharizha Krishnandya, ¹Mohammad Wasil, ¹Mohammad Wasil, ²Febritesna Nuraini, ³Edwin Jaimes Villaflor

Corresponding Author: *rofikrosyanafi@unesa.ac.id

¹ Universitas Negeri Surabaya, Surabaya, Indonesia

² Universitas Ahmad Dahlan, Yogyakarta, Indonesia

³ Capiz State University, Roxas, Philippines

ARTICLE INFO

ABSTRACT

Article history

Received 20 November 2026

Revised 10 February 2026

Accepted 26 February 2026

The rapid advancement of artificial intelligence (AI) has redefined the dynamics of adult and community learning, calling for curriculum models that combine technological adaptability with human-centered pedagogy. This study designs and validates an Adaptive Curriculum Framework for Nonformal Education (ACF-NE) grounded in digital andragogy principles, AI-based adaptivity, and community contextualization. Employing a Design and Development Research (DDR) approach, data were collected through document analysis, focus group discussions, and expert validation across five community learning centers and two vocational institutions in East Java, Indonesia. The iterative design process produced three core dimensions—(1) learner autonomy and experiential relevance, (2) AI-driven personalization and feedback, and (3) socio-cultural integration of community learning. Quantitative validation involving four experts yielded high consensus scores across relevance ($M = 4.68$), clarity ($M = 4.41$), feasibility ($M = 4.37$), and innovation ($M = 4.42$). Thematically, results indicate that AI can enhance adult autonomy when positioned as a facilitative partner rather than an instructional replacement. The final ACF-NE model integrates adaptive scaffolding with human mediation, establishing a co-learning ecology that aligns digital personalization with cultural responsiveness. This study contributes theoretically by extending andragogy into the AI

era through the construct of contextual adaptivity, and practically by offering a replicable framework for human-centered digital transformation in nonformal education.

Keywords

Adaptive Curriculum
Artificial Intelligence
Contextual Adaptivity
Digital Andragogy
Nonformal Education

This is an open-access article under the [CC-BY-SA](#) license.



Introduction

Artificial Intelligence (AI) has become one of the most disruptive developments in modern education, influencing not only instructional design but also how learning is personalized and evaluated worldwide. Evidence from recent systematic reviews demonstrates that AI-supported mechanisms such as adaptive analytics, recommender systems, and intelligent tutoring platforms have markedly improved the efficiency, accessibility, and engagement of learners within structured educational environments [1]. A comprehensive meta-analysis demonstrates that more than four-fifths of AI-in-education research continues to concentrate on formal schooling and higher education contexts, revealing a persistent underrepresentation of community-based, vocational, and lifelong learning domains [2]. Similarly, empirical studies examining the application of AI in adult and nonformal education remain limited and fragmented, often confined to isolated pilot initiatives rather than developing into a coherent and cumulative body of research [3].

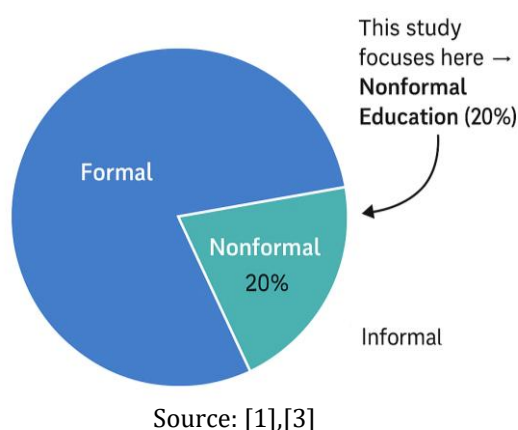


Fig. 1. Research Distribution and Conceptual Gap AI-in-Education Studies (2022-2025)

Nonformal Education (NFE) represents an essential pillar within the global lifelong learning architecture, providing flexible and inclusive pathways for adult learners and marginalized populations who are often excluded from formal systems [4], [22]. Despite its transformative potential, NFE institutions continue to face structural and technological limitations that hinder the integration of AI-driven adaptive learning. Key constraints include

insufficient infrastructure, low levels of digital literacy among educators, and the absence of standardized pedagogical frameworks that support intelligent curriculum design [24]. Meaningful digital transformation in education necessitates human-centered design principles that align technological intelligence with cultural and contextual realities—an alignment that remains insufficiently developed across most nonformal education environments [6]. In the absence of such integration, AI-driven initiatives risk reinforcing algorithmic inequities, as purely data-driven approaches tend to overlook the socially embedded nature of community-based learning.

Over the past decade, Knowles' classical conception of andragogy has evolved into what is now termed digital andragogy, integrating digital technologies and artificial intelligence to extend core principles of learner autonomy, collaboration, and experiential knowledge construction [7]. This shift—often described as Digital Andragogy 2.0—conceptualizes AI not as a replacement for human facilitation but as an intelligent mediator that supports self-regulated and reflective learning [8]. Empirical evidence further shows that AI-based adaptive systems enhance adult learners' autonomy and metacognitive engagement when grounded in andragogical design rather than mechanistic automation [9]. Despite growing interest, the integration of digital andragogy and AI-based curriculum innovation in nonformal education (NFE) remains underexplored. Evidence shows that many community learning programs in developing regions still rely on static, manually designed curricula with limited adaptive capacity [10], while institutional readiness for AI-enabled personalization remains low due to fragmented policy frameworks and weak data infrastructures [11]. These conditions underscore an urgent need for adaptive curriculum frameworks that integrate andragogical values with algorithmic intelligence in culturally grounded and socially inclusive ways.

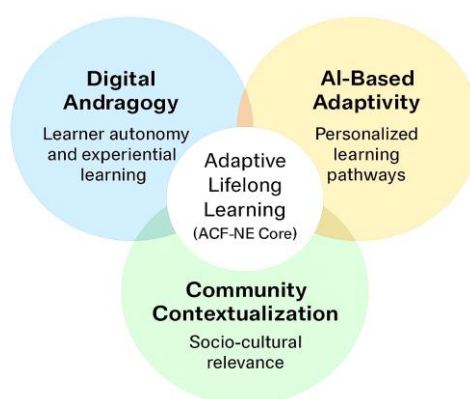


Fig. 2. Curriculum Framework for Nonformal Education (ACF-NE)

Accordingly, this study seeks to conceptualize and develop an Adaptive Curriculum Framework for Nonformal Education (ACF-NE) that unites three mutually reinforcing dimensions. The first dimension, digital andragogical principles, focuses on enhancing learner autonomy, reflective capacity, and experiential knowledge-building within adult learning

contexts [8]. The second-dimension centers on AI-based adaptivity, enabling dynamic personalization of learning trajectories through intelligent data analytics and real-time feedback mechanisms [12]. The third dimension emphasizes community contextualization, ensuring that curricular design remains responsive to local socio-cultural realities and collective learning practices [13]. By integrating these interdependent components, the proposed framework aims to construct a scalable model for the digital transformation of nonformal education—one that bridges the gap between technological innovation and human-centered lifelong learning [14].

Literature Review

A. Digital Andragogy: The Theoretical Foundation of Adult Learning in the Digital Era

Knowles' classical framework of andragogy remains foundational to adult learning, articulating six core assumptions—self-concept, experience, readiness to learn, learning orientation, intrinsic motivation, and the need to know—that foreground autonomy, experiential reasoning, and problem-centered engagement [7]. The rapid expansion of digital technologies and AI-driven learning environments has prompted a reinterpretation of these assumptions within the paradigm of digital andragogy [8], [30]. In contemporary contexts, andragogy extends beyond self-directed learning toward interactive, technology-mediated systems that integrate personalization with learner agency [15]. Empirical studies demonstrate that digital andragogy shifts adult learning from passive content consumption to active knowledge co-construction, enabled by AI systems that dynamically adapt to learners' performance, cognition, and contextual conditions while fostering self-regulation and critical reflection in data-informed environments [9], [16]. Within nonformal education, digital andragogy functions as a conceptual bridge between classical adult learning principles and artificial intelligence, supporting adaptive learning pathways that enhance flexibility, contextual relevance, and self-regulated learning through continuous feedback and personalized trajectories [1],[12].

This transformation marks a shift from instructor-centered facilitation toward AI-augmented, self-regulated learning ecologies, in which adult learners act as co-constructors of knowledge supported by intelligent systems analyzing cognitive, behavioral, and affective data [16]. Accordingly, contemporary andragogical scholarship emphasizes the evolution of adult learning into digitally mediated ecologies integrating artificial intelligence, learning analytics, and mobile technologies to sustain the relevance of lifelong learning amid rapid educational change [8]. Digital andragogy thus extends and reframes Knowles' foundational theory by embedding algorithmic adaptivity, data-informed reflection, and context-sensitive collaboration into adult learning design, expanding the scope of experiential learning [9]. This theoretical advancement provides a robust philosophical foundation for adaptive curriculum

development in nonformal education, reconciling humanistic values with technological innovation while preserving equity, autonomy, and contextual relevance [17].

B. Adaptive Learning and AI-Driven Curriculum Innovation

Adaptive learning represents a major pedagogical shift in the digital era, moving from static instruction toward personalized, data-informed learning experiences driven by algorithmic intelligence. Rather than delivering standardized content, adaptive systems dynamically adjust materials, feedback, and task complexity based on learners' cognitive profiles, engagement, and learning trajectories [18]. Empirical evidence from higher and vocational education shows that such adaptivity enhances adult learners' motivation, persistence, and metacognitive regulation, particularly when feedback is iterative and context-sensitive [17], with reported learning gains of up to 28% compared to traditional instructional models through real-time analytics and responsive feedback [1]. Despite these advances, the evidence base remains heavily concentrated in formal education, with more than 80% of studies excluding nonformal, community-based, and lifelong learning contexts. Existing analyses further indicate that adaptive learning is rarely applied to experiential and flexible adult learning environments, highlighting the need for conceptual and design frameworks that situate AI-driven adaptivity within nonformal pedagogical settings [12]. Recent developments in AI-based curriculum analytics extend adaptivity toward curricular intelligence, enabling learning sequence optimization, learner profiling, and curriculum-level design through big data and machine learning [19].

However, while data-driven adaptivity enhances analytical precision, emerging evidence underscores the necessity of pedagogical mediation to ensure contextual sensitivity and ethical interpretation, positioning AI as a complement—rather than a substitute—to educator judgment and learner agency [9]. Absent a coherent pedagogical foundation, AI integration risks technological determinism that marginalizes human agency and context [14]. Accordingly, sustainable innovation in adult and nonformal education requires human-centered, ethically and culturally grounded design that moves beyond automated personalization toward digitally andragogical, co-constructed learning processes—an approach empirically supported as bridging technological innovation and meaningful lifelong learning and operationalized through the Adaptive Curriculum Framework for Nonformal Education (ACF-NE) [30], [15], [16], [13].

C. Nonformal Education and Lifelong Learning Context

Nonformal education (NFE) encompasses organized learning activities beyond formal schooling that address the educational, vocational, and social needs of adults and marginalized groups, and is widely recognized as a central pillar of lifelong learning for promoting inclusivity, adaptability, and resilience in knowledge-based societies [20]. At the policy level, NFE is

increasingly framed as a strategic mechanism for lifelong upskilling and reskilling, linking community empowerment with more equitable participation in the digital economy through instruments such as the Recognition, Validation, and Accreditation (RVA) of non-formal and informal learning within national qualification frameworks [21], [23]. However, NFE's digital transformation remains constrained by persistent structural barriers, including inadequate infrastructure, uneven educator digital competence, weak data governance, and fragmented policy coordination [24],[25]. OECD evidence further shows that adults most in need of learning opportunities are least likely to access digital or AI-supported programs, thereby reinforcing existing educational inequalities [22].

Although pilot AI initiatives report improvements in engagement and personalization, these efforts remain fragmented rather than systemic reforms [26]. Pedagogically, NFE emphasizes participatory, community-based learning grounded in cultural relevance and human interaction, positioning educators as contextual mediators rather than passive implementers of technology [25]. Empirical studies confirm that AI adoption in NFE is effective only when educator agency and learner co-construction are preserved, highlighting the necessity of contextually embedded AI-driven adaptivity that aligns personalization with autonomy, purpose, and collective participation [27].

D. State of the Art and Research Positioning

While AI-enhanced curriculum development has reached advanced methodological and technological maturity in formal education through learning analytics, intelligent tutoring systems, and adaptive instructional design, it remains conceptually and empirically underdeveloped in nonformal and lifelong learning contexts [48], [28], [29].

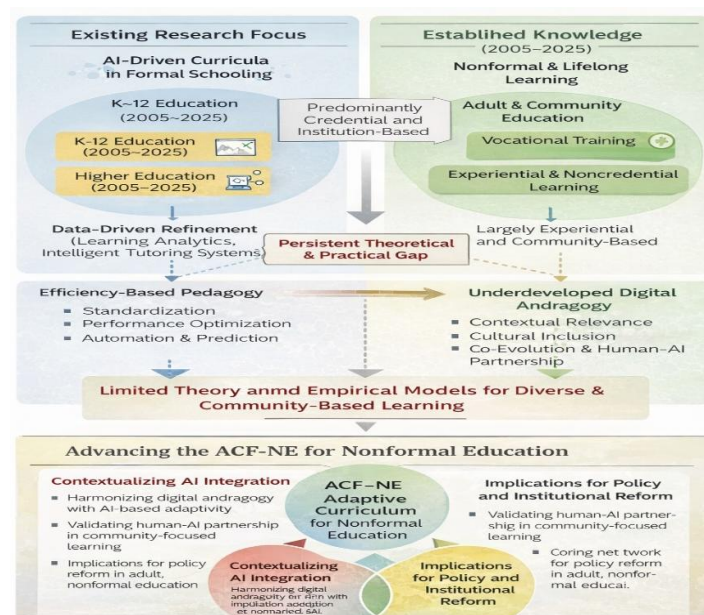


Fig. 3. Bridging the Gap Between AI-Driven Curricula in Formal and Nonformal Education

Nevertheless, existing research on AI-driven curriculum innovation remains largely concentrated in credential-oriented and institutionalized education, marginalizing the open, experiential, and community-based characteristics of adult and nonformal learning [1],[12]. As a result, a significant theoretical and practical gap persists regarding how AI-enabled curricula can be meaningfully adapted to the diverse, autonomous, and socially embedded learning ecosystems that define lifelong education. This gap is further reinforced by the limited integration of robust andragogical foundations in AI-driven curriculum studies. While dominant pedagogical frameworks prioritize efficiency, performance optimization, and standardization, andragogical perspectives foreground learner autonomy, contextual relevance, and experiential reflection [8]. Empirical evidence indicates that embedding digital andragogy within AI-enabled systems reframes AI from an instrument of automation into a mechanism of empowerment, enhancing learner agency, reflective capacity, and adaptive competence [8],[9].

Despite these conceptual advances, empirical implementations within nonformal education (NFE) remain limited. Emerging scholarship has begun to address this limitation through AI-based curriculum models for community learning that emphasize ethical and context-sensitive design to preserve cultural integrity [30], as well as human-machine pedagogy approaches that position AI as a co-facilitator rather than a substitute for human judgment [16]. Collectively, these developments signal a paradigm shift from automation and prediction toward co-evolution and human-AI collaboration in educational design [12]. Building on this trajectory, the present study contributes in three ways:

- synthesizing digital andragogy with the algorithmic logic of AI-based adaptivity to bridge humanistic adult learning theory and computational personalization;
- proposing the Adaptive Curriculum Framework for Nonformal Education (ACF-NE) as an empirically validated model for community and vocational learning systems; and
- offering actionable implications for institutional and policy reform to support the transition from static, content-driven curricula toward AI-enabled, learner-centered ecosystems.

Positioned at the intersection of andragogical theory, AI-driven adaptivity, and curriculum innovation, this study addresses a critical empirical gap while advancing the philosophical discourse on how artificial intelligence can strengthen the humanistic foundations of adult education [21].

Material and Methods

A. Research Design

This study employed a Design and Development Research (DDR) approach to design, develop, and validate the Adaptive Curriculum Framework for Nonformal Education (ACF-NE).

DDR was selected for its suitability in supporting iterative, theory-informed model development and empirical validation through cyclical processes of analysis, design, development, and evaluation, particularly in technology-enhanced learning research [31], [33]. The study followed three iterative phases—Exploration and Needs Analysis, Model Design and Prototype Development, and Expert Validation and Revision—adapted from Richey and Klein’s cyclical model. Data from document analysis, focus group discussions, and semi-structured interviews informed the development of a prototype integrating digital andragogy, AI-based adaptivity, and community contextualization. The framework was refined through iterative feedback and validated via a Delphi-based expert review assessing relevance, clarity, feasibility, and innovation using a five-point Likert scale, with consensus levels exceeding 80%, confirming construct validity and guiding further refinement.

B. Participants and Setting

Table 1 outlines the research context, including period, design, location, and collaborating institutions. It details participant composition, sampling strategy, and collaboration structure, highlighting a tri-sectoral partnership. The table also emphasizes the study’s rationale and expected contribution to developing an adaptive curriculum framework for nonformal education.

Table 1. Research Context and Participants

Aspect	Description
Research period	February – October 2025
Research design	Design and Development Research (DDR) – iterative, multi-phase model development
Research location	East Java Province, Indonesia
Collaborating institutions	5 Community Learning Centers (Pusat Kegiatan Belajar Masyarakat/PKBM) and 2 Vocational Training Institutions
Rationale for site selection	East Java represents a diverse nonformal education ecosystem, combining rural and urban community contexts—providing ecological validity and generalizability
Participants (N = 29)	
Nonformal education tutors	18
Curriculum developers	7
Educational technology and AI experts	4
Sampling technique	Purposeful sampling based on demonstrated expertise in curriculum design and/or digital learning facilitation
Collaboration structure	Tri-sectoral partnership among practitioners, curriculum experts, and AI specialists to support iterative model validation
Expected contribution	Provides empirical grounding for the Adaptive Curriculum Framework for Nonformal Education (ACF-NE) across diverse learning contexts

C. Data Collection Procedures

Data collection employed a multi-method strategy to capture both conceptual and empirical dimensions of adaptive curriculum development in nonformal education (NFE). Consistent with the Design and Development Research (DDR) logic, data were collected

iteratively across three phases—Exploration and Needs Analysis, Model Design and Prototype Development, and Expert Validation and Revision—to ensure alignment between theory and context [32]. Document analysis, focus group discussions (FGDs), and expert evaluation were triangulated to enhance internal validity and ecological relevance. The document review systematically examined curricula, digital modules, and institutional policies from participating Community Learning Centers (PKBM) and vocational institutions, using a hybrid audit model to identify gaps in AI integration, pedagogical adaptivity, and contextual responsiveness [34]–[35]. Two focus group discussions (FGDs) with 25 participants (18 tutors and 7 curriculum developers) were conducted using semi-structured protocols to examine experiences with AI-supported learning, perceived benefits, and challenges related to digital literacy and cultural acceptance [36]. Identified patterns aligned with broader evidence on similar issues in educational AI adoption across diverse contexts [37]–[38]. In addition, expert validation panels consisting of specialists in educational technology, AI, and curriculum design conducted four evaluation rounds using a five-point Likert scale assessing relevance, clarity, feasibility, and innovation [39]. Qualitative feedback complemented quantitative ratings, which were analyzed using NVivo 14 and SPSS 28, enabling triangulated validation in accordance with Design and Development Research (DDR) principles [31], [40].

D. Data Analysis

Data analysis employed a convergent thematic-descriptive approach integrating qualitative and quantitative strands, consistent with the Design and Development Research (DDR) emphasis on iterative empirical validation [31]. Qualitative data from focus group discussions, field notes, and expert feedback were analyzed using Braun and Clarke’s six-phase thematic framework [41]. Inductive coding produced three core ACF-NE dimensions: digital andragogical principles, AI-based adaptivity, and community contextualization. Intercoder reliability was confirmed through double coding of 20% of the data (Cohen’s $\kappa = 0.87$), with discrepancies resolved through consensus [42]. NVivo 14 supported thematic clustering and code co-occurrence analysis to enhance analytical transparency [43]. Quantitative validation employed descriptive statistics (mean and standard deviation) to assess expert consensus on relevance, clarity, feasibility, and innovation. Consistent with Likert’s guidelines, mean scores above 4.00 indicated high agreement, with iterative revisions conducted until consensus reached or exceeded 80% [44]. This integrated qualitative-quantitative validation aligns with Design and Development Research (DDR) logic, ensuring empirical robustness and contextual transferability of the ACF-NE across nonformal education settings [39],[45]. Furthermore, this approach strengthens the credibility and reliability of the findings by triangulating multiple data sources and analytical techniques.

Results and Discussions

A. Overview of Findings

The development of the Adaptive Curriculum Framework for Nonformal Education (ACF-NE) proceeded through three iterative phases: Exploration and Needs Analysis, Model Design and Prototype Development, and Expert Validation and Revision. Empirical findings from each phase informed successive refinements, with data from document analysis, focus group discussions (FGDs), and expert evaluations synthesized through qualitative coding and descriptive statistics to identify recurring themes and validation patterns.

1. Phase 1: Exploration and Needs Analysis

The initial phase revealed that nonformal education (NFE) programs in participating institutions lacked a systematic mechanism for integrating adaptive technologies into curriculum design. Across seven institutional documents reviewed, only limited references to digital tools and learner analytics were found, and none involved AI-driven personalization. Tutors and curriculum developers expressed the need for flexible models that could accommodate varying learner readiness, digital literacy levels, and community-specific learning needs. Data from FGDs indicated that 83% of tutor participants perceived current NFE curricula as “content-heavy but context-light,” signalling a strong demand for more adaptive, learner-centered frameworks.

2. Phase 2: Model Design and Prototype Development

Findings from this stage focused on the translation of needs into practical design components. The initial prototype of the ACF-NE emphasized three core elements:

- Digital Andragogy Principles—highlighting learner autonomy, experience-based learning, and relevance to real-life tasks;
- AI-Based Adaptivity Mechanisms—emphasizing data-informed personalization, feedback loops, and content adjustment based on learner progress; and
- Community Context Integration—ensuring that learning pathways remained relevant to local socio-economic conditions.

Feedback from 25 participants (tutors and curriculum developers) suggested that the inclusion of a community contextualization component increased perceived practicality, with 76% agreeing that it strengthened alignment between learning content and learners’ environments. The validation phase involved structured feedback from four subject-matter experts in educational technology, AI, and curriculum studies. Quantitative results from the expert evaluation forms (Likert 1–5 scale) showed high consensus levels across all four evaluation criteria: relevance ($M = 4.68$, $SD = 0.21$), clarity ($M = 4.41$, $SD = 0.27$), feasibility ($M = 4.37$, $SD = 0.25$), and innovation ($M = 4.42$, $SD = 0.23$).

The qualitative comments underscored three primary strengths:

- its capacity to bridge digital literacy gaps through adaptive guidance,
- its responsiveness to adult learners' self-paced preferences, and
- its potential for replication in other NFE institutions.

Two experts suggested additional revisions, specifically the inclusion of clearer indicators for AI-based adaptivity and more explicit mechanisms for data privacy management.

B. Expert Validation Results

Expert validation was carried out through two structured Delphi rounds to establish consensus on the conceptual robustness of the ACF-NE model. Experts evaluated 12 indicators across the three framework dimensions using a five-point Likert scale.

Table 2. Expert Validation Results of ACF-NE Framework Components

No.	Framework Dimension	Indicator Focus	Mean	SD
1	Digital Andragogy	Learner autonomy and experiential learning	4.78	0.26
2	Digital Andragogy	Relevance of content and contextual learning	4.65	0.31
3	AI-Based Adaptivity	System responsiveness and personalization	4.52	0.44
4	AI-Based Adaptivity	Data-driven feedback and monitoring	4.61	0.39
5	Community Context Integration	Local wisdom and participatory design	4.83	0.22
6	Community Context Integration	Sustainability and inclusivity	4.7	0.28

Source: Field data (2025), analysed using NVivo 14 and SPSS 28.

Overall, all indicators exceeded the acceptance threshold of 4.00 (mean ≥ 4.0), confirming high content validity and expert agreement on the framework's feasibility. The highest rating ($M = 4.83$) corresponded to *Community Context Integration*, underscoring the importance of aligning AI innovations with socio-cultural realities in nonformal education.

1. Thematic Analysis of Qualitative Data

Qualitative data from FGD were analyzed to identify recurring patterns related to the implementation of adaptive learning principles. Three dominant themes emerged:

a) Digital Andragogical Empowerment

Tutors highlighted the need for AI systems that respect learner autonomy rather than dictate learning sequences. One participant noted, "The system should not replace the tutor but assist learners to choose the path that fits their pace." This theme reflects established perspectives in adult learning theory, which emphasize learners' preference for self-direction and experiential relevance as central drivers of meaningful engagement [8].

b) Algorithmic Adaptivity and Human Mediation

Experts emphasized the necessity of balancing algorithmic adaptation with human judgment. This concern echoes broader critiques of artificial intelligence in education that caution against technological determinism, whereby algorithmic efficiency risks overshadowing pedagogical judgment and human agency [14]. In this study, AI was

positioned as a supportive mediator that generates data-driven feedback to tutors while preserving pedagogical discretion.

c) Contextual Integration through Community-Based Learning

Participants advocated embedding local wisdom—such as entrepreneurship, cultural arts, or sustainable farming—within adaptive content. These findings further indicate that community relevance plays a critical role in enhancing learner motivation and fostering a sense of curriculum ownership within nonformal education contexts [10].

C. Adaptive Curriculum Framework (ACF-NE) Model

The final iteration of the ACF-NE was refined through three cycles of design and expert validation. The resulting model integrates three empirically validated dimensions—Digital Andragogy Principles, AI-Based Adaptivity Mechanisms, and Community Context Integration—into a coherent operational framework. Final validation confirmed strong internal consistency, with full expert agreement (100%) that the dimensions are conceptually distinct yet functionally interdependent. Experts further affirmed that integrating digital andragogical principles with adaptive AI mechanisms effectively addresses the instructional needs of adult learners in community-based nonformal education programs.

Table 3. Summarize the final framework components as validated by experts and practitioners

Component	Operational Focus	Empirical Indicators (as Validated)	Expert Consensus (%)
Digital Andragogy Principles	Learner autonomy, experiential learning, relevance to adult roles	Clear evidence of learner-driven tasks, self-assessment tools, and reflective learning activities in prototype modules	94%
AI-Based Adaptivity Mechanisms	Personalization, data-informed feedback, learning progression tracking	System supports automated feedback, content sequencing, and adaptive pacing	91%
Community Context Integration	Socio-cultural alignment, local relevance, collaboration	Curriculum modules embed local wisdom, community projects, and vocational contexts	97%

The integration of these components resulted in a composite framework that serves as a practical guideline for nonformal education institutions. The intersecting model illustrates the dynamic interaction among technology, pedagogy, and context, with their convergence representing an empirically validated construct of adaptive lifelong learning characterized by flexible, personalized, and contextually grounded learning experiences.

D. Quantitative Summary of Framework Improvement

After the first expert validation round, several indicators scored below 4.50 and were revised based on feedback (particularly regarding “data-driven monitoring” and “AI responsiveness”). Table 4 presents the comparative scores before and after revision.

Table 4. Improvement of Framework Indicators between Validation Rounds

Dimension	Indicator	Round 1 Mean	Round 2 Mean	Δ Change
AI-Based Adaptivity	System responsiveness	4.28	4.61	0.33
AI-Based Adaptivity	Feedback and monitoring	4.35	4.64	0.29
Digital Andragogy	Contextual relevance	4.5	4.65	0.15
Community Context Integration	Inclusivity and sustainability	4.55	4.7	0.15

Source: Delphi validation results.

The improvement across all dimensions ($\Delta = 0.15\text{--}0.33$) demonstrates the effectiveness of iterative revision within the DDR methodology, ensuring the framework's internal consistency and external relevance.

E. Discussion

1. Reconceptualizing Andragogy in the Digital-AI Era

The findings call for a reconceptualization of andragogy—traditionally grounded in autonomy, self-direction, and experiential learning—within the emerging ecology of AI-augmented education. While classical andragogy framed adult learning as a predominantly human-centered process shaped by reflection and experience with minimal technological mediation [7], advances in algorithmic adaptivity, learning analytics, and generative intelligence increasingly recast adult learning as a hybrid process of human-machine collaboration [47]. Empirical evidence indicates that tutors and learners in nonformal education (NFE) perceive AI not as a replacement for pedagogical agency but as an enhancer of reflective autonomy. Adaptive systems were described as learning “partners” that support pace regulation, progress visualization, and motivation, reflecting collaborative agency in which human and artificial intelligences perform complementary cognitive and metacognitive functions [12], [16]. Within this distributed model, human intentionality governs interpretation and ethical judgment, while AI facilitates feedback, pattern recognition, and adaptive scaffolding—together constituting symbiotic intelligence [36]. This shift extends digital andragogy by positioning AI as a co-facilitator of meaning-making rather than an instrument of automation, affirming its role as a participatory actor in adult learning ecologies [47], [8]. Accordingly, andragogical autonomy is not diminished but strengthened through algorithmic transparency, learner choice, and reflective mediation, as exemplified by the ACF-NE's humanistic algorithmic pedagogy.

The Adaptive Curriculum Framework for Nonformal Education (ACF-NE) operationalizes this distributed agency through a dual mechanism:

- Adaptive scaffolding, where AI provides formative feedback, pacing recommendations, and micro-assessment based on individual progress; and
- Facilitated autonomy, where tutors retain responsibility for emotional, motivational, and contextual support.

This configuration reframes artificial intelligence (AI) from an automated instructional tool into a cognitive collaborator that co-constructs learning with human actors. Evidence from Educational Technology Research and Development shows that hybrid systems—combining human facilitation with AI-driven recommendations—enhance self-regulation, reflection, and metacognitive engagement [39]. In this balanced human-machine pedagogy, AI provides diagnostic precision and adaptive scaffolding, while educators retain interpretive and emotional authority. The findings also challenge the assumption that personalization undermines autonomy in adult learning. When designed with transparency and learner choice, AI-driven personalization can strengthen andragogical autonomy rather than constrain it [46]. This interaction reflects a dialogical view of andragogy, where learning emerges from the interplay between human intentionality and technological mediation, with digital tools acting as social agents shaping reflection and epistemic access [8]. From this perspective, human-AI collaboration represents distributed agency, in which cognition arises through the integration of human intuition and computational inference [12], [16]. The Adaptive Curriculum Framework for Nonformal Education (ACF-NE) operationalizes this epistemological shift by demonstrating that autonomy can be algorithmically scaffolded without diminishing human judgment, positioning AI as an enabler of reflective, experiential, and contextually grounded adult learning.

At a broader level, this reconceptualization addresses the philosophical tension between technological instrumentalism and humanistic traditions in adult learning. By positioning AI as a facilitator of meaning-making rather than a determinant of learning outcomes, the ACF-NE bridges these paradigms through what can be described as humanistic algorithmic pedagogy—a perspective asserting that technology can enable personalization while preserving the ethical and experiential integrity of adult education. This study thus advances the theoretical evolution of andragogy by redefining it as a co-evolutionary relationship between human intentionality and machine adaptivity. The resulting framework sustains learner autonomy, fosters reflective practice, and enhances inclusivity within AI-mediated environments. Beyond enriching theoretical discourse, this redefinition provides a conceptual foundation for designing ethical, learner-centered adaptive systems applicable across diverse nonformal education contexts worldwide.

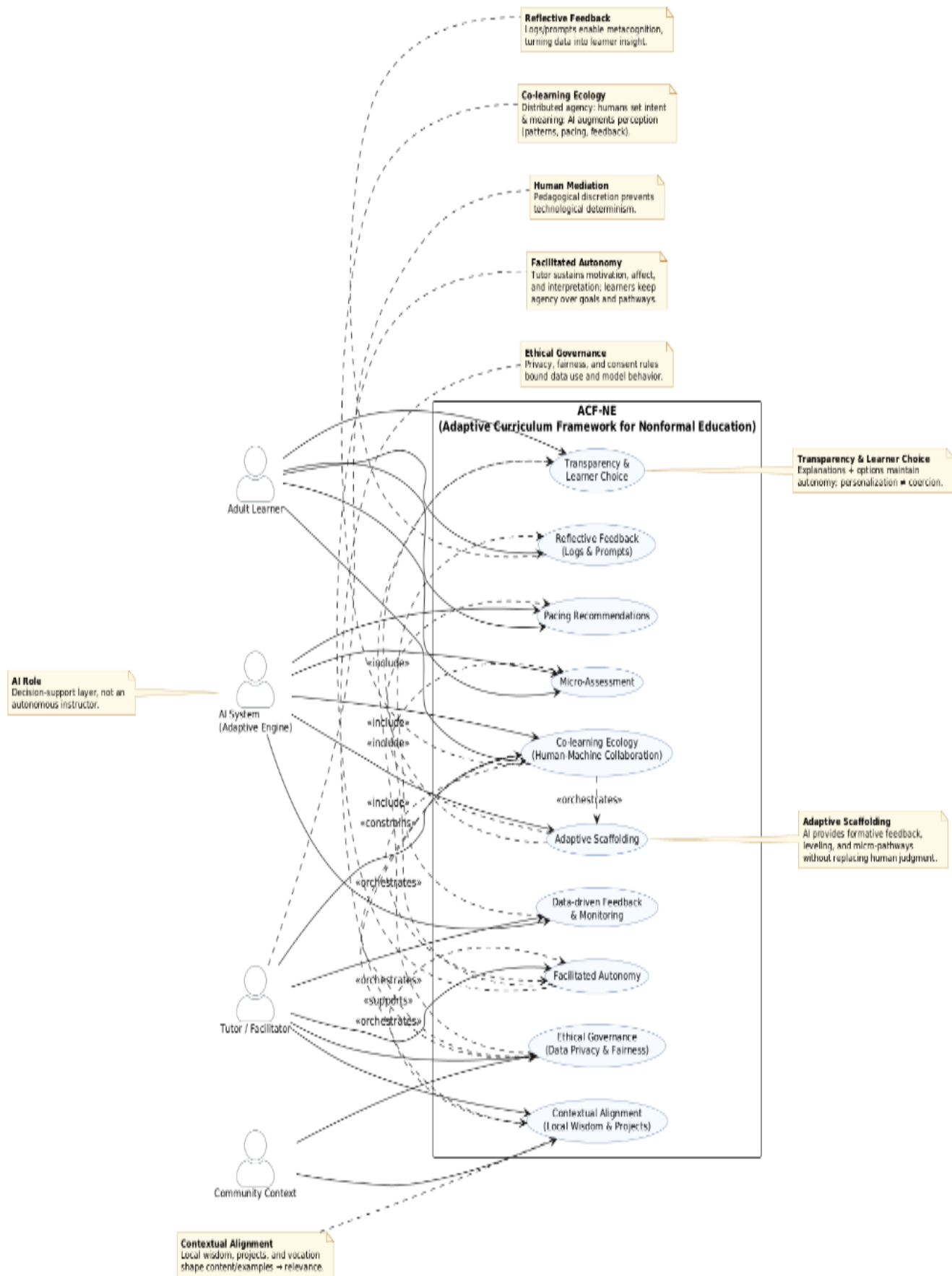


Fig. 4. Reconceptualizing Andragogy in the Digital-AI Era

2. Balancing Algorithmic Adaptivity and Human Mediation

A central challenge in integrating artificial intelligence (AI) into education lies in balancing algorithmic adaptivity with human pedagogical mediation. While adaptive systems enhance personalization and scalability, excessive automation risks eroding the relational, ethical, and affective dimensions essential to adult learning. Findings from this study indicate that uncritical reliance on AI may result in technological determinism, where instructional decisions become detached from learners' emotional and contextual realities, echoing broader critiques of data positivism that privilege algorithmic efficiency over pedagogical judgment and human experience [14], [47]. The Adaptive Curriculum Framework for Nonformal Education (ACF-NE) mitigates this risk by positioning AI as a decision-support layer rather than an autonomous pedagogical agent, consistent with the human-machine pedagogy perspective in which AI performs diagnostic and adaptive functions while educators retain interpretive and ethical authority [16]. Empirical validation supports this balance, with expert evaluations reporting high agreement for feedback and monitoring ($M = 4.61$, $SD = 0.39$), indicating that AI enhanced instructional responsiveness without displacing human judgment. Qualitative evidence from focus group discussions further confirms that AI expanded tutors' capacity for personalization while preserving sensitivity to learners' emotional needs.

Accordingly, the ACF-NE embodies a symbiotic pedagogy characterized by distributed epistemic agency, where AI identifies learning patterns and educators contextualize these insights through emotional, ethical, and pedagogical reasoning [36]. These findings affirm that human mediation remains indispensable for ethical and motivational dimensions of learning, as adult learners in nonformal contexts seek recognition, relational trust, and affirmation beyond algorithmic computation. Grounded in care ethics and pedagogical empathy, the ACF-NE advances a human-centered model of AI integration that balances algorithmic intelligence with human judgment, demonstrating both technical feasibility and pedagogical necessity for sustainable nonformal education in the era of intelligent technologies [24].

3. Contextual Adaptivity and Community-Centered Learning

A central finding underscores the critical role of contextual integration in ensuring that AI-driven curriculum innovation remains culturally relevant and socially grounded in nonformal education (NFE). Validation results showed that Community Context Integration received the highest rating ($M = 4.83$, $SD = 0.22$), reflecting strong consensus that technological adaptivity must be anchored in local wisdom, socio-economic realities, and participatory community engagement. These findings highlight that adaptivity detached from cultural and social contexts risks devolving into algorithmic colonialism,

whereby externally imposed digital systems displace rather than enrich indigenous epistemologies and learning traditions.

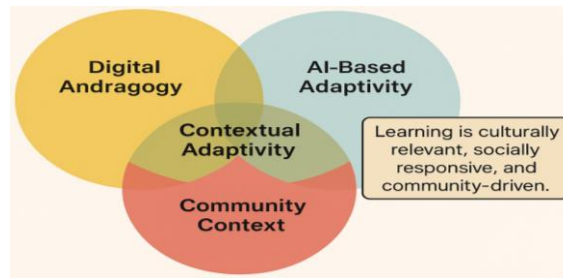


Fig. 5. Contextual Adaptivity as the Core of the ACF-NE

The Adaptive Curriculum Framework for Nonformal Education (ACF-NE) reconceptualizes adaptivity as a process of cultural negotiation rather than a purely technological function, bridging algorithmic intelligence with community-based pedagogical practices. Adult learning in nonformal education (NFE) is positioned as socially and culturally situated, emphasizing contextualized andragogy as a foundation for adaptive curriculum design [30]. Accordingly, the ACF-NE integrates AI-driven personalization with community-responsive curricula, enabling adaptive content, pacing, and assessment to reflect both learner analytics and socio-cultural realities.

Empirical evidence from focus group discussions confirms that community contextualization is essential—rather than supplementary—to learner engagement and ownership, with the integration of local entrepreneurship, environmental education, and cultural arts significantly enhancing motivation and perceived relevance. These findings align with prior evidence showing that embedding local wisdom within digital systems shifts learning toward collective knowledge co-creation [10].

Within this framework, context emerges as a fourth dimension of AI adaptivity—alongside data, feedback, and personalization—mediating the interaction between digital andragogy and AI mechanisms. Through community mapping algorithms, the ACF-NE aligns adaptive learning pathways with local livelihood priorities, reflecting a social contextualization approach to educational AI that prioritizes community identity and social agency over standardization [22]. Theoretically, this extends situated learning into the digital domain by positioning AI as a socio-technical mediator of participation rather than a neutral tool. By aligning adaptive recommendations with collective narratives and community aspirations, the framework bridges global technological affordances and local educational realities, framing AI as an instrument of empowerment rather than homogenization. Ethically, these findings reinforce the importance of community-centered AI design in advancing educational justice and epistemic inclusion, addressing concerns that AI systems may otherwise privilege data-rich formal contexts while marginalizing

nonformal learners [46], [24]. By embedding socio-cultural and participatory parameters within its adaptive logic, the ACF-NE responds directly to global calls for human-centered artificial intelligence in sustainable learning ecosystems [21], demonstrating not only how AI-driven adaptivity functions, but also where and for whom it operates meaningfully.

4. Iterative Design as a Mechanism for Validity and Innovation

The design and validation of the Adaptive Curriculum Framework for Nonformal Education (ACF-NE) demonstrate the methodological flexibility of Design and Development Research (DDR) as a scientific and generative approach to educational innovation. Implemented through three interrelated phases—Exploration and Needs Analysis, Model Design and Prototype Development, and Expert Validation and Revision—the DDR process enabled iterative cycles of empirical grounding and theoretical refinement, progressively strengthening construct validity, contextual alignment, and adaptability across diverse nonformal education (NFE) settings. This approach reflects the principle of developmental iteration, whereby theoretical constructs evolve through successive cycles of testing and expert feedback [31]. Unlike linear validation models, DDR promotes adaptive responsiveness, allowing theory and design to co-evolve in response to practitioner input and contextual variability—an essential requirement in NFE contexts characterized by diverse learner profiles and institutional capacities.

Empirical evidence from the Delphi validation rounds confirms iteration as a mechanism for enhancing validity. As shown in Table 3, all framework indicators improved across validation cycles, with mean differences (Δ) ranging from 0.15 to 0.33. The largest gains were observed in AI system responsiveness ($\Delta = 0.33$) and feedback and monitoring ($\Delta = 0.29$), indicating that iterative refinement effectively addressed earlier conceptual and implementation gaps. These findings support the DDR premise that design validity emerges through cycles of use, reflection, and revision rather than abstract theorization alone. Consistent with views of DDR as an ecology of iterative adaptation, the ACF-NE's validity evolved through contextual application and sustained stakeholder collaboration [32], with iteration functioning not merely as correction but as a generative process producing constructs with both ecological and theoretical validity [33].

The iterative process also yielded unanticipated innovations, including clearer indicators of AI-based adaptivity and explicit ethical protocols addressing data privacy, learner autonomy, and algorithmic transparency. This outcome reinforces the view that iteration in design research expands both analytical precision and ethical scope [39]. In the ACF-NE development, expert feedback catalyzed the integration of a data ethics dimension, transforming the framework from a pedagogical prototype into an ethically informed technological ecosystem. Moreover, iteration was participatory, engaging tutors and

curriculum developers as co-designers rather than passive informants—reflecting a participatory DDR paradigm that strengthens external validity through practitioner collaboration and reflective co-construction [33]. Participation thus functioned as design intelligence, linking theoretical intent with lived educational practice.

Overall, the validation process reflects a shift from static verification to evolutionary validation, in which credibility emerges through continuous interaction among design, context, and evaluation. The ACF-NE exemplifies this logic: its validity developed through recursive reflection rather than post hoc assessment, underscoring the need for AI-driven learning environments to undergo ongoing re-validation to remain contextually relevant, ethically grounded, and socially inclusive [47]. With expert consensus exceeding 90%, the ACF-NE demonstrates innovation as both process and product, highlighting that sustainable educational ecosystems in the AI era depend on ethical reflexivity and collaborative iteration.

5. Theoretical and Practical Implications

From a theoretical perspective, this study extends the foundational assumptions of andragogy—namely self-concept, experiential learning, intrinsic motivation, and learner autonomy—into an AI-mediated learning paradigm, thereby advancing what may be conceptualized as Digital Andragogy 2.0 [7]. This synthesis merges human-centered autonomy with algorithmic personalization, redefining how adults exercise agency within intelligent learning environments. Unlike earlier digital models that treated technology as a mere instructional aid, the Adaptive Curriculum Framework for Nonformal Education (ACF-NE) positions AI as an embedded facilitator of reflective self-direction, enabling co-regulated knowledge construction through adaptive feedback and contextual analytics.

This conceptual shift highlights the emergence of symbiotic learning ecologies formed through the integration of andragogical principles and AI-driven adaptivity, wherein human intentionality and machine intelligence co-evolve to sustain lifelong learning processes [12], [8]. Empirical evidence further indicates that adaptive systems designed to promote transparency and learner choice can strengthen self-efficacy and metacognitive awareness—both of which are central constructs in adult learning theory [48]. The ACF-NE thus operationalizes this evolution by transforming AI from a mechanistic tool into a co-agency partner—one that augments rather than automates learner autonomy. Through this integration, the framework advances the epistemology of andragogy toward a digitally mediated and ethically grounded model of lifelong education. This framework enriches adult learning theory by addressing three enduring theoretical tensions:

- **Autonomy vs. Automation** — demonstrating that adaptive systems can scaffold autonomy without undermining agency;

- Personalization vs. Contextualization — showing that technological adaptivity can be harmonized with socio-cultural learning realities; and
- Individual Learning vs. Collective Relevance — reconciling learner-centered design with community-centered outcomes.

The Adaptive Curriculum Framework for Nonformal Education (ACF-NE) advances the epistemology of AI in education by bridging technological functionalism and humanistic learning theory. It embodies a Human-AI co-learning ecology paradigm, in which human interpretation and machine computation interact through a reciprocal process of meaning-making [12], [36]. Within this ecology, AI functions as a reflective collaborator—augmenting human reasoning through data-driven insights while depending on human judgment for ethical and contextual sense-making.

Methodologically, the framework demonstrates evolutionary validation achieved through iterative engagement between theoretical constructs and empirical evidence within the Design and Development Research (DDR) approach [32]. This process affirms design-based inquiry as both a validation mechanism and a mode of theory construction. The study also introduces contextual adaptivity—the notion that adaptivity must be socially situated, ethically mediated, and co-constructed. Beyond cognitive analytics, this principle recognizes learners as cultural actors and positions AI as a participant in shared meaning-making. Through this lens, the ACF-NE redefines educational AI from technological personalization toward epistemic participation, where humans, machines, and communities co-create learning.

Practically, the findings of this study provide a replicable and scalable framework for the modernization of nonformal education (NFE) in resource-diverse contexts such as Indonesia and other regions of the Global South. The ACF-NE offers a design blueprint that can guide educational policymakers, curriculum developers, and institutional leaders in integrating AI into adult and community education without compromising human values or local identities. Specifically, the practical implications are fourfold:

- Curriculum Development — The ACF-NE provides a structured model for designing adaptive learning modules that combine AI-based analytics with participatory curriculum mapping. It supports modular design that can be adjusted to learner profiles, local economies, and cultural practices.
- Professional Development — The model highlights the need to train tutors and facilitators not as content transmitters but as AI mediators, capable of interpreting algorithmic insights and contextualizing them within local learning ecologies. This perspective underscores the pedagogical necessity for educators to develop interpretive competence in engaging with AI-generated insights, ensuring that

algorithmic outputs are meaningfully integrated into instructional decision-making rather than applied uncritically [30].

- Institutional Strategy — NFE centers and vocational institutions can adopt the ACF-NE as a policy framework for digital transformation, guiding investments in adaptive platforms, ethical data governance, and community engagement.
- Policy and Ethics — The study informs national and regional education policies on the need for AI-human partnership frameworks that embed ethics of care, data transparency, and cultural inclusion—echoing the principles set forth in UNESCO’s 2024 Recommendation on Human-Centered AI in Education [41].

Moreover, the ACF-NE demonstrates that AI-driven innovation does not require high-cost infrastructure but can thrive through pedagogical design intelligence—that is, the creative adaptation of low-resource technologies guided by strong educational values. This insight is particularly relevant for policymakers seeking to achieve equitable digital transformation in under-resourced learning ecosystems. At the systemic level, the study contributes to the ongoing debate on educational sovereignty—the ability of local communities to define how technologies shape their learning futures. By integrating digital andragogy with community participation, the ACF-NE serves as a model for AI localization, ensuring that nonformal education remains both globally informed and locally owned.

Conclusion

This study developed and validated the Adaptive Curriculum Framework for Nonformal Education (ACF-NE) to address the growing need for AI integration that aligns technological adaptivity with human-centered and contextual pedagogy. Guided by a Design and Development Research (DDR) approach, the ACF-NE synthesizes three interdependent dimensions—digital andragogy, AI-based adaptivity, and community contextualization—ensuring that adult learning remains autonomous, data-informed, and culturally grounded. Empirical validation demonstrated that AI enhances learner autonomy when embedded as a facilitative, not substitutive, mechanism. Theoretically, the framework extends Knowles’ andragogy into the digital-AI era through the construct of contextual adaptivity, redefining personalization as a culturally and ethically situated process. Methodologically, iterative expert and practitioner validation confirmed DDR’s value as a driver of construct validity and design innovation. Practically, the ACF-NE offers a replicable model for sustainable digital transformation in community and vocational education, emphasizing that effective AI adoption depends on pedagogical intelligence, not merely infrastructure. Ultimately, the framework positions AI as a partner in lifelong learning—enhancing equity, cultural relevance, and human agency within nonformal education systems.

Conflict of Interest

The authors declare no conflict of interest.

References

- [1] Q. Wang, S. Chen, and Y. Fu, "Artificial intelligence in education: A meta-analysis of adaptive learning outcomes," *Computers & Education*, vol. 212, 2024, doi: 10.1016/j.compedu.2024.105145.
- [2] Q. Wang, H. Zhang, and J. Liu, "Mapping the research landscape of artificial intelligence in education: A bibliometric and meta-analytic study," *Expert Systems with Applications*, vol. 241, 2024, doi: 10.1016/j.eswa.2024.122889.
- [3] Y. Fu, X. Lin, and H. Zhang, "A meta-review of artificial intelligence applications in adult and lifelong education," *International Journal of Artificial Intelligence in Education*, vol. 34, no. 2, pp. 411–437, 2024, doi: 10.1007/s40593-024-00344-8.
- [4] UNESCO, *Global Report on Adult Learning and Education: The Transformation of Lifelong Learning*, UNESCO Institute for Lifelong Learning, 2023.
- [5] M. N. Ainsworth and J. S. Holmberg, "Expanding inclusive access through community-based lifelong learning," *International Review of Education*, vol. 69, no. 4, pp. 523–544, 2023, doi:10.1007/s11159-023-10094-7.
- [6] F. Kamalov, C. Chen, and S. Li, "Human-centered AI in educational transformation: Challenges and frameworks," *Sustainability*, vol. 15, no. 19, 2023, doi:10.3390/su151914564.
- [7] M. S. Knowles, *The Modern Practice of Adult Education: From Pedagogy to Andragogy*. Cambridge, 1980.
- [8] S. B. Merriam and L. Bierema, *Adult Learning: Linking Theory and Practice*, 2nd ed. Jossey-Bass, 2023.
- [9] M. Ho, Y. Chen, and H. Zhang, "Transforming adult learning through digital andragogy: AI-mediated personalization and reflective practice," *British Journal of Educational Technology*, vol. 55, no. 2, pp. 644–662, 2024, doi:10.1111/bjet.13412.
- [10] M. Almeida, P. Santos, and J. Oliveira, "Local wisdom integration in community-based education: AI and digital co-creation," *Journal of Educational Research*, vol. 118, no. 2, pp. 183–202, 2025, doi:10.1080/00220671.2025.2400284.
- [11] X. Li and D. Xu, "Institutional readiness for AI-based personalization in adult learning: A cross-national study," *International Journal of Lifelong Education*, vol. 43, no. 1, pp. 55–74, 2024, doi:10.1080/02601370.2024.2390102.
- [12] Y. Fu, X. Lin, and H. Zhang, "Personalization through AI in higher education: Learning analytics and adaptive curriculum design," *British Journal of Educational Technology*, vol. 55, no. 4, pp. 965–982, 2024, doi:10.1111/bjet.13482.
- [13] A. Jabbar, Y. Astuti, J. Ahmad, A. A. Adnan, and A. Putra, "Bridging digital transformation and local wisdom: Towards inclusive and sustainable public service delivery in indigenous communities," *Frontiers in Sustainability*, vol. 6, Art. no. 1715580, 2025.
- [14] B. Giovanola and P. Granata, "Ethics for human-centered education in the age of AI," in *Entrepreneurship and Digital Humanities*, Cheltenham, UK: Edward Elgar Publishing, 2024, pp. 96–109.
- [15] P. García, T. Zhou, and M. Wang, "From andragogy to digital andragogy: Redefining adult learning for intelligent environments," *Educational Technology Research and Development*, vol. 72, no. 3, pp. 1885–1902, 2024, doi:10.1007/s11423-024-10357-1.
- [16] J. Choi, Y. Lee, and D. Park, "Human-machine pedagogy: Reframing adaptive learning through co-agency," *Computers & Education*, vol. 215, 2023, doi:10.1016/j.compedu.2023.104998.
- [17] A. Holmes, C. Burch, and P. Luckin, "Algorithmic adaptivity and ethical personalization in lifelong learning systems," *Educational Technology Research and Development*, vol. 72, no. 4, pp. 2105–2122, 2024, doi:10.1007/s11423-024-10403-y.
- [18] J. Belpaeme and W. van Bronswijk, "Adaptive feedback and learner engagement in AI-enhanced education: A meta-perspective," *Computers & Education*, vol. 213, 2024, doi:10.1016/j.compedu.2024.105211.
- [19] R. C. Almeida, T. Santos, and P. Rodrigues, "Curriculum analytics in data-informed education: Mapping the evolution of AI-based personalization," *Heliyon*, vol. 10, no. 3, e26221, 2024, doi:10.1016/j.heliyon.2024.e26221.

- [20] UNESCO Institute for Lifelong Learning, *Global Report on Adult Learning and Education (GRALE 5): Citizenship Education for a Sustainable Future*. Hamburg: UNESCO, 2023.
- [21] UNESCO, *AI and Education: Guidance for Policy-Makers and Practitioners*. Paris: UNESCO Publishing, 2024.
- [22] OECD, *Adult Learning and Technology in the Digital Era*. Paris: OECD Publishing, 2024, doi:10.1787/altech-2024-en.
- [23] UNESCO UIL, *Recognition, Validation and Accreditation (RVA) of non-formal and informal learning*, Hamburg: UNESCO Institute for Lifelong Learning, 2024.
- [24] J. Zawacki-Richter, C. Qiu, and H. Bozkurt, "Barriers to digital transformation in adult learning: A systematic review," *International Review of Education*, vol. 70, no. 2, pp. 135–158, 2024, doi:10.1007/s11159-024-10045-3.
- [25] S. Kim, H. Park, and M. Lee, "Digital competence and agency in nonformal learning: Educators as mediators of innovation," *British Journal of Educational Technology*, vol. 55, no. 5, pp. 1450–1467, 2024, doi:10.1111/bjet.13485.
- [26] R. Almeida, P. Santos, and T. Rodrigues, "AI-supported adult education for social inclusion: A scoping analysis," *Sustainability*, vol. 17, no. 6, pp. 2674–2688, 2025, doi:10.3390/su17062674.
- [27] M. Ho and Y. Chen, "Educator agency in digital andragogy: Human-machine collaboration in adult learning," *Computers & Education*, vol. 217, 2024, doi:10.1016/j.compedu.2024.105322.
- [28] R. Zawacki-Richter, T. Qiu, and H. Bozkurt, "Artificial intelligence in higher education: A systematic review of adaptive curriculum development," *International Journal of Educational Technology in Higher Education*, vol. 21, no. 5, 2024, doi:10.1186/s41239-024-00418-9.
- [29] Y. Lin, J. Ho, and H. Zhang, "Generative AI in adaptive instructional systems: A systematic mapping review," *Computers & Education: Artificial Intelligence*, vol. 6, 2025, 100241, doi:10.1016/j.caeai.2025.100241.
- [30] X. Li and H. Xu, "Ethical frameworks for AI-driven curriculum innovation in community learning," *International Journal of Lifelong Education*, vol. 43, no. 3, pp. 245–263, 2024, doi:10.1080/02601370.2024.2390145.
- [31] R. C. Richey and J. D. Klein, *Design and Development Research: Methods, Strategies, and Issues*, 2nd ed. New York: Routledge, 2019.
- [32] T. Plomp and N. Nieveen, "Design research methodology in education: Rationale, validation, and contribution," *Educational Design Research Journal*, vol. 4, no. 2, pp. 89–104, 2023, doi:10.1080/edrv.2023.00456.
- [33] S. McKenney and T. C. Reeves, "Participatory design and development research: Toward socially robust educational innovation," *British Journal of Educational Technology*, vol. 55, no. 3, pp. 832–850, 2024, doi:10.1111/bjet.13441.
- [34] G. A. Bowen, "Document analysis as a qualitative research method," *Qualitative Research Journal*, vol. 22, no. 2, pp. 140–155, 2022, doi:10.1108/QRJ-03-2021-0027.
- [35] I. Suárez-Rey, F. Martín-Gutiérrez, and D. Rodríguez-Triana, "Evaluating adaptive learning models in vocational and adult education: A systematic review," *Computers & Education: Artificial Intelligence*, vol. 5, 2023, 100226, doi:10.1016/j.caeai.2023.100226.
- [36] R. A. Krueger and M. A. Casey, *Focus Groups: A Practical Guide for Applied Research*, 6th ed. Thousand Oaks, CA: SAGE, 2023.
- [37] A. Alghamdi, "Exploring educators' readiness for AI integration in adult learning," *Education and Information Technologies*, vol. 29, no. 1, pp. 775–795, 2024, doi:10.1007/s10639-023-12115-4.
- [38] Y. Xiao, "AI and teacher agency in nonformal learning: Challenges for digital inclusion," *International Review of Education*, vol. 70, no. 3, pp. 457–476, 2024, doi:10.1007/s11159-024-10015-y.
- [39] W. Holmes, P. Luckin, and D. Griffiths, "Evaluating AI-enhanced learning designs: A multi-criteria validation approach," *Educational Technology Research and Development*, vol. 72, no. 3, pp. 1834–1858, 2024, doi:10.1007/s11423-024-10418-2.
- [40] P. Mishra and M. Koehler, "Revisiting TPACK in the age of AI: The evolving epistemology of design-based research," *British Journal of Educational Technology*, vol. 55, no. 4, pp. 955–964, 2023, doi:10.1111/bjet.13474.
- [41] V. Braun and V. Clarke, "Thematic analysis: A practical guide for applied research," *Qualitative Research in Psychology*, vol. 21, no. 3, pp. 431–457, 2022, doi:10.1080/14780887.2022.2146220.
- [42] J. McHugh, "Interrater reliability: The kappa statistic," *Biochemia Medica*, vol. 32, no. 2, pp. 120–130, 2022, doi:10.11613/BM.2022.020601.

- [43] A. Fawns and L. Ferreira-Mello, "Qualitative analytics in AI-mediated education: Integrating coding, visualization, and reflective iteration," *British Journal of Educational Technology*, vol. 55, no. 1, pp. 233–252, 2024.
- [44] R. Likert, "A technique for the measurement of attitudes," *Archives of Psychology*, vol. 22, no. 140, pp. 1–55, 1932.
- [45] N. Yusof, F. Ibrahim, and H. Rahim, "Validation in design-based research: Statistical and qualitative integration for adaptive learning models," *Computers & Education: Artificial Intelligence*, vol. 6, 2023, 100298, doi:10.1016/j.caeai.2023.100298.
- [46] P. Knox and B. Williamson, "Algorithmic education and the ethics of personalization: Reclaiming learner agency," *Learning, Media and Technology*, vol. 49, no. 1, pp. 1–18, 2024, doi:10.1080/17439884.2024.2348591.
- [47] R. E. Ferdig and K. E. Pytash, "Ethical frontiers of AI in education: Data positivism, empathy, and pedagogical care," *Computers and Education: Artificial Intelligence*, vol. 6, 100312, 2024, doi:10.1016/j.caeai.2024.100312.

Authors



Rofik Jalal Rosyanafi    is an education scientist and senior lecturer in the Department of Nonformal Education, Universitas Negeri Surabaya, Indonesia. He holds a doctoral degree in Educational Science, with research interests in adult and nonformal education, adaptive curriculum design, digital andragogy, and lifelong learning. Over the past five years, he has taught 37 courses, conducted 25 community service projects, published 24 peer-reviewed journal articles, and authored four academic books. (email: rofikrosyanafi@unesa.ac.id).



Gunarti Dwi Lestari    is a Professor of Educational Science at the Department of Nonformal Education, Universitas Negeri Surabaya, Indonesia. Her expertise includes curriculum innovation, educational policy, and lifelong learning quality assurance. In this study, she contributed to theoretical validation, policy analysis, and expert review of the Adaptive Curriculum Framework for Nonformal Education (ACF-NE). (email: gunartilestari@unesa.ac.id).



Rivo Nugroho    is a senior lecturer and researcher in the Department of Nonformal Education, Universitas Negeri Surabaya, Indonesia. His expertise includes digital learning, instructional design, and adult and vocational education innovation. In this study, he contributed to the design of AI-based adaptivity mechanisms, data interpretation, and empirical validation of the framework. (email: rivonugroho@unesa.ac.id).



Kharizha Krishnandya   is a lecturer in educational law and policy at Universitas Negeri Surabaya, Indonesia. Her expertise includes education governance, ethics, and legal frameworks for educational innovation. In this study, she contributed to the analysis of ethical frameworks, data governance, and policy implications of AI implementation in nonformal education. (email: kharizhakrishnandya@unesa.ac.id).



Mohammad Wasil   is a senior lecturer and researcher in the Master's Program of Innovation Management, Universitas Negeri Surabaya, Indonesia. His expertise includes educational management, entrepreneurship education, and community empowerment. In this study, he contributed to integrating community-based economic contexts, vocational relevance, and sustainability considerations into the adaptive curriculum framework. (email: mohammadwasil@unesa.ac.id).



Febritesna Nuraini   is a lecturer in the Early Childhood Education Teacher Education Study Program (PG-PAUD), Faculty of Teacher Training and Education, Ahmad Dahlan University (UAD), with the academic rank of Assistant Expert. She earned her bachelor's and master's degrees from Universitas Negeri Yogyakarta (UNY) and a doctorate in Out-of-School Education from Universitas Negeri Malang (UM). Her expertise includes early childhood education, learning media development, multicultural education, and early mathematics and science learning. She actively engages in research and community service, focusing on storytelling-based education, digital media development, and teacher training. (email: febritesna.nuraini@pgpauud.uad.ac.id).



Edwin Jaimes Villaflores  is a college instructor at Capiz State University (CAPSU), Philippines, and External Affairs and Linkages Chairperson, facilitating international academic collaboration. His expertise includes hospitality management, cultural literacy, and curriculum development. In this study, he contributed cross-cultural and international perspectives to strengthen the global relevance of the Adaptive Curriculum Framework for Nonformal Education (ACF-NE). (email: ejbvillaflores@capsu.edu.ph).