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A Conceptual Framework for Intelligent Learning Systems in Microfinance Education

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Peer Review Information	Abstract
<i>Submission: 12 Jan 2026</i> <i>Revision: 03 Feb 2026</i> <i>Acceptance: 25 Feb 2026</i> Keywords <i>Intelligent Learning Systems, Microfinance Education, Low-Resource Settings, Framework Development, Microfinance Providers</i>	Microfinance education aims to improve financial decisions, but many programs struggle to turn knowledge into lasting behavior change because learners vary in their skills. They also offer few practice opportunities and often use the same instruction for all learners in low-resource settings. Design guidance is needed to adapt instruction, create feedback loops, and link learning to microfinance workflows. This paper presents a modular framework, an evidence map, and a staged pilot roadmap informed by literature mapping and stakeholder workshops. Deliverables include component definitions, a context adaptation table, measurement templates, and decision criteria aligned to pre and post measures. The manuscript makes no original empirical claims, limits outcomes to individual learner knowledge and application, and serves as a design tool for program teams and microfinance providers.

Introduction

This paper explains how microfinance education can improve individual financial decisions and livelihood outcomes by strengthening knowledge and practical application (Amirtha, 2024). Evidence links stronger financial knowledge to better choices about saving, borrowing, and asset allocation, and to improved household financial management. Many programs still struggle to turn knowledge into lasting behaviour change because learners start with different skills, they have few chances to practice, and instruction often treats everyone the same. We propose intelligent learning systems: adaptive, feedback-driven platforms that model learner performance, tailor practice, and link learning to microfinance workflows and routine service delivery.

Building on theory and inputs from practitioners, the paper presents a modular framework for intelligent learning systems, a labelled diagram

that defines each component, and a mapped evidence table that rates support strength for each component (Fong, 2024). We also provide guidance for adapting the design to context and a staged pilot roadmap that specifies prototype, small pilot, and scale horizons with governance checkpoints. Readers should treat the framework as a design tool rather than as evidence of causal program effects. The manuscript makes no original empirical claims and limits outcomes to individual learner knowledge and application.

Literature Review

This review places microfinance education in three literatures that inform intelligent learning systems that adapt instruction to learners' needs in adult microfinance programs. Systematic surveys of financial technology, or FinTech, in microfinance map digital innovations but note unclear adoption drivers and implementation gaps (Offiong et al., 2024). Reviews of financial

literacy programs compare delivery modes and stress the need for adaptive, locally relevant curricula and outreach strategies (Mancone et al., 2024). Research linking literacy to sustainable investment shows how learning outcomes shape longer-term financial choices and institutional sustainability (Senaya, 2024).

Microfinance education and inclusion needs

This section examines the education needs of adult learners in low-resource microfinance programs and what success looks like for learners and providers. Field studies report gaps in basic financial management and low literacy. These gaps reduce participation and limit economic agency (Kyeyune & Ntayi, 2025). Rural surveys find that literacy affects inclusion more than access to digital finance alone, which suggests education should accompany technology access (Sam-Abugu et al., 2025). Practical barriers include limited devices, intermittent connectivity, time constraints, and distrust of financial providers.

Design requirements include modular short lessons tied to everyday financial choices. Provide basic literacy support and use simple language. Favor offline-first delivery and low-bandwidth operation. Allow flexible scheduling. Include fraud awareness and practical budgeting exercises. The system should adapt instruction to each learner profile so content and feedback change as learners progress. Gamified scenarios and repeated practice can improve engagement and help learners apply skills in the real world (Czech et al., 2024). Measurement should use brief before-and-after assessments, simple completion rates, and observable behaviour proxies.

Intelligent learning and adult learning evidence

This section summarizes evidence on how intelligent learning systems, that is systems which adapt instruction by modeling a learner's knowledge and giving feedback, can support adult financial literacy in microfinance education. Reviews and surveys report potential benefits for access, personalized pacing, and automated practice, especially for underserved groups and small businesses, but evidence for sustained behaviour change is still limited (Opeyemi et al., 2024). Practical gains are clearest for operational efficiency and for scalable tutoring functions in constrained settings where monitoring is needed. Key constraints for deployment include unequal device and network access, data privacy risks, and the need to align algorithms and content with local regulations and religious norms in some settings (Lasmiatun & Manteghi, 2025). Banking and program reviews show efficiency and wider access gains, but the link from personalized

instruction to lasting financial behaviour change is tentative and needs pilot evaluation and governance checkpoints to check fairness and data use. Adaptation rules should specify roles.

Methodology

We developed the framework through a repeatable sequence of literature mapping, theory synthesis, and stakeholder workshops focused on microfinance education. A global analysis of publication and citation patterns in financial literacy and behaviour (Dimensions.AI, 2014-2024) and thematic trend mapping guided which components to prioritize and where gaps remain (R. M. Kumar, 2024). All search strings, inclusion rules, analytic scripts, and workshop instruments are recorded in Appendix A and B templates so others can reproduce and adapt the process. Components were given strength ratings using predefined scoring criteria and combined into a mean evidence score, Eq. (1). Versioned code, software environment files, and instrument templates accompany the manuscript for reuse.

$$r = \frac{1}{K} \sum_{k=1}^K s_k \quad (1)$$

How we built the framework

We constructed a conceptual framework for intelligent learning systems in microfinance education through a stepwise process. First, we conducted a systematic literature search across public databases, removed duplicate records, and screened results using inclusion rules based on relevance, empirical support, and fit to adult microfinance education. We included empirical studies, systematic reviews, and practitioner case reports. We excluded work outside adult microfinance education or without descriptions of learning or delivery components. Screening decisions and the search strings are archived in Appendix A.

We then coded the screened sources into a component library using a shared coding guide that linked components to evidence and practitioner notes. We combined those codes with adult learning and behaviour change theory to define component boundaries and propose links between components. Stakeholder workshops with practitioners and learners helped validate labels, showed implementation constraints, and suggested rules for adaptation in practical settings. The component list and links appear in Figure 1 and evidence strengths are summarized in Table 1. Full logs and analysis scripts are available in Appendix A.

Key terms and system boundaries

This section defines key terms and the system boundary for intelligent learning systems in microfinance education. An intelligent learning

system (ILS) is a software enabled learning service that adapts instruction to adult learners by combining three components: learner modeling, adaptive instruction, and feedback loops. Learner modeling is a profile of knowledge, skills, and activity history used to select content and track progress. Adaptive instruction is automated sequencing of activities based on the learner profile. Feedback loops pass information between the learner model and instruction so the system updates content. Labels in the diagram match the definitions.

Fig. (1). Personalization refers to tailoring of content, pacing, and assessment to a learner and results from the combined operation of learner modeling, adaptive instruction, and feedback. Inputs inside the boundary include pretest scores, interaction logs, and product or account records used with consent. Outputs inside the boundary include tailored learning content, learner progress reports, and facilitator prompts. Governance, network infrastructure, and provider business rules lie outside the ILS boundary. Unit of analysis is individual learner.

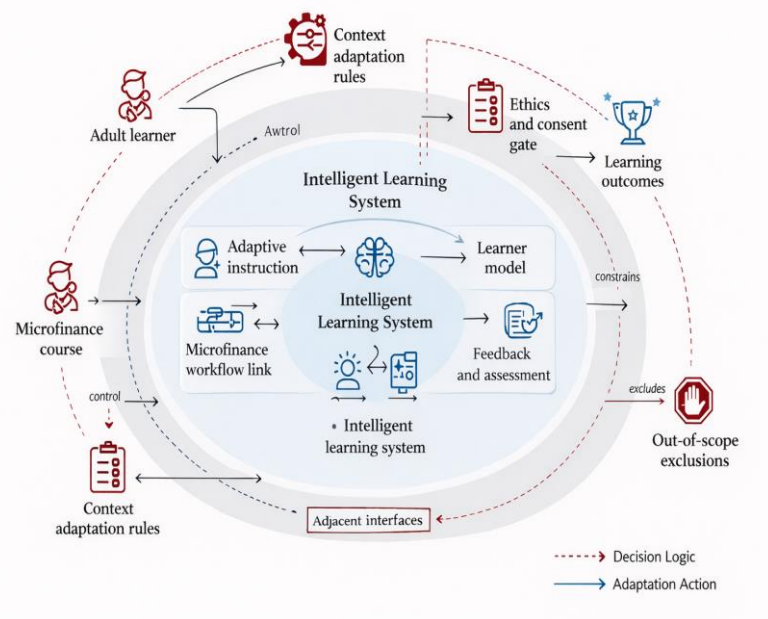


Fig. 1. ILS scope and exclusions

How we rated the evidence

This section defines the rules we used to link framework components to supporting sources and to assign consistent evidence strength categories. We used a three-tier scheme: strong requires three or more independent sources, moderate requires one to two sources, and weak covers practitioner reports or plausibility evidence. Components must have at least one documented citation or a practitioner case. We record measurement and construct definitions to improve comparability and follow calls for standardized literacy measures (Rekha et al., 2024).

Each component was linked using a registered protocol and classified by evidence type and strength. Peer-reviewed empirical studies count as corroborating sources. Practitioner case reports are recorded as practice evidence and receive weak strength unless an independent empirical study corroborates them. The mapping notes record measurement and construct definitions for each source so readers can

compare measures. The coverage and strength columns indicate supporting scope rather than causal inference.

Results

This section presents artifacts for designing and testing intelligent learning systems in microfinance education. We define intelligent learning systems as integrated systems combining adaptive instruction, learner models, feedback loops, personalization, and connections to microfinance workflows. Deliverables include a conceptual framework with definitions, an evidence mapping table linking each component to supporting sources and a strength rating, and a context adaptation table pairing boundary indicators with actionable steps. Measurement templates include a data dictionary, versioned pre-post-tests, and a normalized gain formula. Eq. (2) defines the normalized pre-post learning gain used in the templates. Appendices document the calculation protocol and a pilot roadmap with governance checkpoints.

$$g = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} \quad (2)$$

Framework components and links

This section presents the componentized model of intelligent learning systems for microfinance education and explains each link. We define intelligent learning systems as software that adapts instruction using profiles of learner knowledge and needs, feedback, personalization, and links to microfinance workflows. The framework groups elements into core inputs, processes, and outcomes for financial literacy and adoption. We adopt adoption and literacy constructs from FinTech studies and treat digital financial literacy as a mediating pathway

(Adhikari et al., 2024). The labelled diagram and link definitions are shown in Fig. (2).

We propose three testable hypotheses to guide future pilots and to clarify which links the diagram will investigate. First, adaptive instruction that adjusts to learner needs will improve financial literacy outcomes compared with nonadaptive delivery. Second, increases in digital financial literacy will mediate the relation between system use and application of financial skills (Adhikari et al., 2024). Third, explicit links to microfinance service workflows that reduce transaction friction will increase learner uptake and real-world use of new practices. Each hypothesis will be defined in advance.

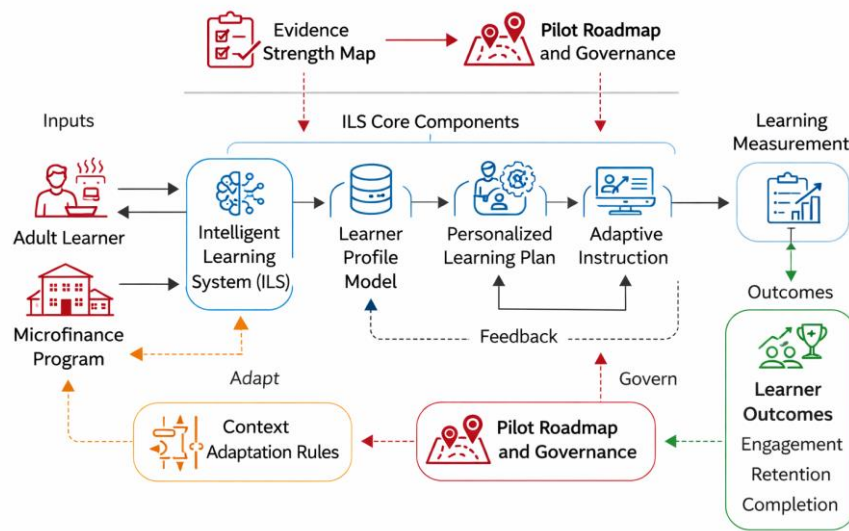


Fig. 2. Conceptual framework overview

Evidence mapping for each component

The evidence mapping links each framework component for intelligent learning systems in microfinance education to supporting sources and a categorical strength rating. The mapping records the component name, supporting citations, evidence type, strength rating, and a brief justification. The predefined scoring criteria define strong as 3 or more independent sources, moderate as 1 to 2 sources, and weak when support is practitioner-only or plausibility. Each component must have at least one documented citation or a practitioner case to be listed as supported. Empirical examples include links from financial and digital literacy to outcomes (González-Prida et al., 2025; Imjai et al., 2025; Kurniasari & Lestari, 2024). Tab. (1).

Mapped results show that components linking financial literacy, digital literacy, and FinTech adoption to firm outcomes are supported across multiple country studies. Analyses from Indonesia and Palopo City report positive associations between financial literacy, FinTech adoption, and business performance, which further supports those components (Kurniasari & Lestari, 2024; Pratama et al., 2024; Ratnawati et al., 2024; Reddy et al., 2024). Decision analysis and structural modeling work identify and prioritize specific literacy drivers that inform component selection and adaptation (P. Kumar et al., 2024; Mohapatra et al., 2025). Components based mainly on practitioner experience receive weak ratings, with a short justification recorded in the mapping for reviewer verification.

Table 1. Component evidence strength mapping

Table 1 Field	What To Record	How Strength Is Rated
Component	Named framework component (for example: adaptive	Each component must have at least 1 documented citation or a

	instruction, learner modeling, feedback loops, personalization, integration with microfinance workflows)	documented practitioner case to be listed as supported
Supporting Citations	Citation keys for sources that support the component (from the literature mapping)	Count independent corroborating sources: 3 or more sources supports Strong; 1 to 2 sources support Moderate
Evidence Type	Type of support used for the component, such as documented citation, practitioner case, or plausibility	Practitioner-only or plausibility support is rated Weak under the rubric
Strength Rating	One of: strong, moderate, weak	Strong: 3 or more independent corroborating sources; Moderate: 1 to 2 sources; Weak: practitioner-only or plausibility
Justification	Short reason for the rating (why the listed sources support the component)	Explain the rating using the rubric basis (source count and type), and note residual uncertainty via the strength category

Context boundaries and adaptation actions

The framework targets adult learners in microfinance education and specifies where it is likely to apply and where adaptation is needed to avoid poor performance in low-resource settings (Singh et al., 2024). Observable context boundaries include digital readiness, gender representation, missing data, core activity completion, and timestamp integrity, and each has a concrete action listed in Tab. (2). For example, items with >20% missing responses are flagged. Core summaries require $\geq 80\%$ completion to be included in primary summaries, and staffing and cost constraints affect applicability.

Cross-country factors such as education completion, income, and household debt shape where the framework can transfer and should be treated as conditions for adaptation (Nogueira et al., 2025). Adaptation triggers combine macro drivers and user-level constraints so programs adjust delivery, assessment, and resourcing when indicators cross thresholds in the boundary table. Recommended measures include low-bandwidth content, offline materials, facilitated small groups, oversampling of underrepresented learners, flexible completion windows, and local facilitator training and support. See Fig. (3).

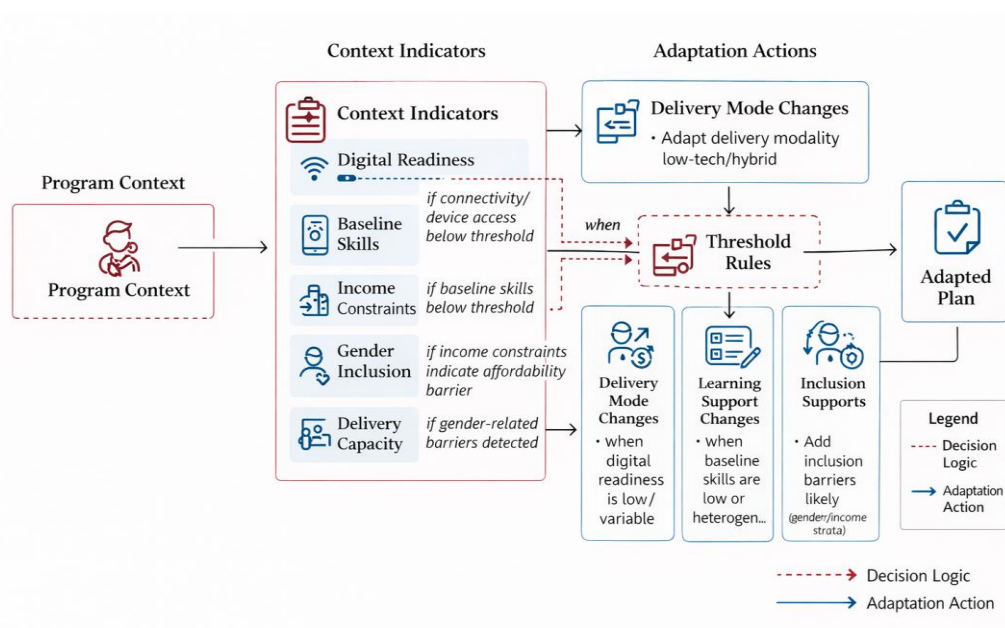


Fig. 3. Adaptation indicators and actions

Table 2. Boundary indicators and adaptation actions

Context Boundary	Indicator Or Threshold	Adaptation Action
Digital Readiness	Low, medium, high readiness based on connectivity, device access	Plan digital_readiness_slices; run robustness checks to digital-access variability
Gender Representation	Sampling strata include gender; oversample women where enrollment <50%	Purposive stratified sampling by gender and digital-access strata; oversample women where enrollment <50%
Item Missingness	>20% missing responses on an item	Flag items with >20% missing responses
Core Activity Completion	>=80% completion required for primary summaries	Require >=80% completion of core activities for primary summaries
Timestamp Integrity	Non-monotonic or duplicate timestamps	Flag non-monotonic or duplicate timestamps

Measures and data sources for pilots

We translate the framework into concrete measures for microfinance pilots by defining constructs, indicators, and data sources. Primary learning outcomes are financial literacy knowledge and use, measured with separate pre and post-tests and behavioral proxies. Secondary implementation outcomes cover engagement, retention, inclusion, and covariates for interpretation. Measurement rules require separate pre and post instrument versions, record instrument IDs, randomize item order where applicable, and check timestamp integrity. Primary summaries include only learners with >=80% completion of core activities.

We align the multidimensional construct of digital financial literacy with these measures, drawing on evidence that defines several literacy dimensions (Bhat et al., 2024) and on work that examines machine learning assisted screening as a low-cost option to identify low literacy groups (Zhu, 2024). Tab. (3). Sampling and labelling use purposive stratified cells by gender and digital readiness. We oversample women when enrolment is <50% and record starting literacy, numeracy, digital access, and program intensity as covariates for outcome summaries and for planned additional checks.

Table 3. Pilot measures and data sources

Construct	What To Measure	How Measured	Data Source	Quality And Validity Notes
Financial Literacy	Knowledge and application change	Pre/post tests, behavioral proxies	Pilot instruments, pre/post forms	Use distinct pre/post forms, track instrument_version IDs, randomize item order where applicable
Engagement	Participation during learning activities	Completion of core activities, timestamped activity records	ILS exports and instrument responses	Check timestamp integrity, flag non-monotonic or duplicate timestamps
Retention And Completion	Sustained participation through the program	Core activity completion rate	Program learning records for consenting learners	Require >=80% completion of core activities for primary summaries
Inclusion	Differences across learner groups	Stratify by gender, income strata, digital readiness slices	Enrollment and baseline descriptors with consent	Use purposive stratified sampling, oversample women where enrollment <50%

Key Covariates	Baseline factors for interpretation	Baseline literacy/numeracy, digital access, socioeconomic status, program intensity	Baseline assessments and learner-reported descriptors	Use these covariates when summarizing outcomes and checking robustness to digital-access variability
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Discussion

We present a conceptual framework for intelligent learning systems in microfinance education and what it enables for educators, implementers, and researchers. For educators it clarifies component roles such as learner modeling (estimates knowledge and needs), adaptive instruction (tailors content), and feedback loops, and links them to mapped evidence so design choices align with that evidence. For implementers it defines boundary conditions and actionable steps to guide deployment across resource and digital readiness constraints. For researchers it identifies measurable outcomes and checks that help others repeat pilots. Remaining unknowns are contextual effectiveness, operational cost trade-offs, and implementation fidelity until staged pilots carry out the roadmap.

Practical design and deployment guidance

Program teams can use the framework to guide design choices and a staged rollout in microfinance training. Start by mapping the primary learning outcome, financial literacy knowledge and ability to apply it, to the framework components so each design choice links to a measurable pre/post-test or to a behavioral proxy. Choose delivery modes and personalization only after confirming access, staff capacity, and minimal resource needs. Define criteria for moving between phases and include ethics checkpoints. Low-resource settings, prefer offline modules, facilitator-led group sessions, and paper or SMS assessments. Use local training to reduce the need for devices or internet. Monitor data quality with timestamped exports and thresholds for missing responses. Track participant completion. Iterate content across prototype, small pilot, and scale phases lasting 0-3 months, 3-6 months, and 6-18 months. Link each change to the primary outcome. Use Table 2 and Appendix B for boundary indicators and templates.

Limits and how to monitor them

Key limits to transferability and credibility arise when the framework is piloted in microfinance programs. We list main threats and concrete monitoring and mitigation actions. Cross-sectional designs and self-reported measures can bias uptake estimates. Use behavioral proxies,

time-stamped logs and follow-up interviews to triangulate (Mei et al., 2024). Local differences in resources and digital readiness affect feasibility. Monitor connectivity, device access and staff capacity to trigger adaptation actions in Table 2. Variation in implementation and contamination between delivery groups can obscure signals. Register assignment rules in advance, randomize item order, and keep assignment logs, instrument version identifiers, and timestamps. Track drop-out and report completion by key characteristics, then run sensitivity checks defined in advance. Reduce social desirability bias by using behaviour-based outcomes and anonymous response modes. Measure starting technology skill and include it as a moderator defined in advance to interpret uptake patterns (Mei et al., 2024).

Path to policy and future research

This subsection gives a practical path from pilot evidence to adoption of intelligent learning systems, defined here as adaptive instruction that tracks learners and gives tailored feedback for microfinance education. Adoption should be based on consistent gains in financial literacy, higher use of digital financial services, and measurable improvements in women's financial decision making and empowerment (Mishra et al., 2024; Showkat et al., 2024). Policymakers and donors should require repeatable measures and clear equity reporting before endorsing scale.

In practice, microfinance providers and program implementers should run controlled pilots and collect pre and post measures of literacy, digital finance use, retention, and decision making. Independent evaluators should check the findings and report to funders and regulators. Funders should link staged funding to predefined evidence thresholds and governance checkpoints. Researchers should publish methods and plans for data access to support transparent policy deliberation and practical adoption (Mishra et al., 2024; Showkat et al., 2024).

Ethics and data statements

This paper presents a framework for intelligent learning systems in microfinance education and an ethics and data plan. Funding and roles are disclosed. IRB approval and informed consent

will be required before piloting. Privacy will be protected by de-identification, hashed identifiers, an offline mapping key, and data minimization. Framework assets Figure 1, Table 1, Table 2, and a data dictionary are shared. Pilot data will be available under restricted access with use agreements (Omokhoa et al., 2024; Omowole et al., 2024).

Acknowledgements

This study developed a conceptual framework for intelligent learning systems in microfinance education, emphasizing staged piloting, clear operational definitions, and evidence mapping. We thank practitioners, policymakers, and learner representatives who contributed perspectives in workshops and consultations, and we acknowledge partner organizations and administrative staff for logistical support. We also thank peer reviewers and colleagues for their constructive feedback.

Appendices

The appendices provide materials and templates to reproduce the conceptual framework for intelligent learning systems in microfinance education. Appendix A gives the protocol for calculations, search queries, literature selection log and scripts that reproduce the evidence

mapping in Table 1. Appendix B includes the staged pilot decision table, governance checkpoints, consent and survey templates that operationalize Table 2 and the pilot roadmap.

Appendix A Framework build steps

This appendix gives the step-by-step protocol used to rebuild the evidence map that supports the framework. It lists the registered bibliographic search queries and the exact export commands. It describes the deduplication and screening workflow and the codebook with inclusion and exclusion rules. It also describes the scripted steps that convert bibliography exports into the component-to-citation mapping used in Table 1. Scripts, logs, and raw exports are archived.

Appendix A also documents the stakeholder engagement protocol, including the sampling rationale, workshop instruments, consent templates, and anonymized summaries of practitioner input. It includes the literature selection log with source counts, the code used to reproduce screening and evidence strength assignments, and notes on versioning and random seeds so another team can rerun the pipeline and regenerate the mapping outputs and audit records.

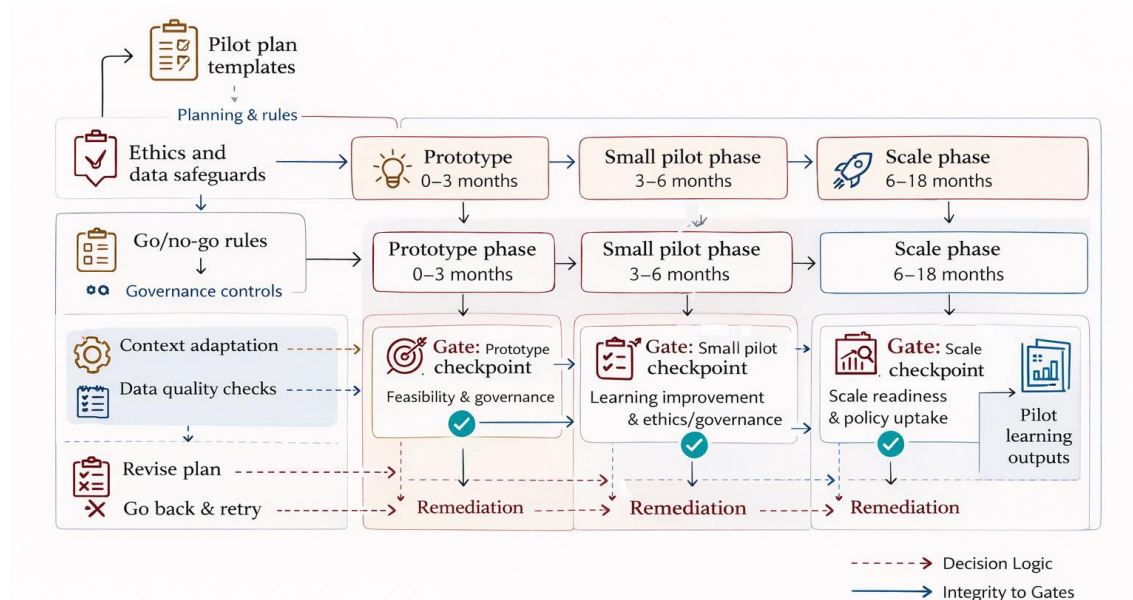


Fig. 4. Staged pilot roadmap

Conclusion

The paper presents a modular, evidence-linked framework and a staged pilot roadmap for intelligent learning systems in microfinance education. Using systematic literature mapping, theory synthesis, and stakeholder workshops, the study defines core components, measures,

and rules for adapting to context, and it links each component to graded evidence and appendices for checking methods. The framework shows where adaptive instruction and learner models may be useful and highlights evidence gaps and feasibility limits in low-resource settings. Immediate next steps are controlled prototypes

and pilots guided by predefined thresholds, ethics checkpoints, and shared measurement templates. The framework supports responsible, testable adoption rather than claims of universal effectiveness.

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