

# A Systematic Review Evaluating the Effectiveness of AI-Driven Personalized Learning Systems in Enhancing Mother-Tongue Education in Uzbek Primary Education

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## ABSTRACT

Artificial intelligence (AI) is increasingly transforming educational systems by enabling personalized and adaptive learning environments. However, despite these advancements, many AI-based learning tools are primarily designed for dominant global languages, leaving low-resource language contexts with limited access to effective AI-supported education. This study examines the effectiveness of AI-driven personalized learning systems in supporting mother-tongue education in Uzbek primary education. A systematic literature review was conducted to analyze existing studies on AI in early childhood education, personalized learning technologies, and AI-supported native language learning. The findings indicate that AI has the potential to enhance learning through personalized instruction, improved engagement, and culturally relevant educational content. However, significant gaps remain in the development of AI systems for low-resource languages and culturally diverse educational environments. This study highlights the need for inclusive and culturally responsive AI design that supports mother-tongue education in Uzbekistan and addresses issues such as dataset limitations, bias, and accessibility.

## INTRODUCTION

The rapid advancement of artificial intelligence has fundamentally reshaped educational landscapes across the globe. AI-powered learning systems now offer unprecedented opportunities for personalized learning, educational content that adapts dynamically to individual students' needs, preferences, and learning pace (Pesek et al., 2022) enabling more efficient pathways to academic achievement, improved engagement, and support for teachers in assessment. Yet, beneath this technological promise lies a critical inequity: the vast majority of AI-driven educational tools are designed for dominant global languages, particularly English, leaving millions of children who speak low-resource languages, languages for which comparatively little digital text, speech, and annotated data exist to support the development of language

technologies (Ranathunga & de Silva, 2022) without access to the same quality of AI-supported education.

This gap is not merely technological. Considering that children cannot access learning materials in their mother tongue, the consequences extend far beyond inconvenience. Research consistently demonstrates that students learn most effectively when instruction occurs in their first language, particularly during early childhood and primary education years when foundational cognitive and linguistic skills are developing. Children who learn exclusively through a second or foreign language often experience reduced comprehension, lower academic confidence, and diminished connection to their cultural identity. The absence of mother-tongue instruction in educational resources thus represents both an educational disadvantage and a threat to linguistic and cultural preservation.

Uzbekistan presents a compelling case for examining these issues. As a country with over 35 million people and Uzbek as the official state language, the nation has a substantial population of young learners who would benefit from AI-powered educational tools in their native language. However, Uzbek remains classified as a low-resource language in computational and AI contexts, meaning that datasets, language models, and educational applications remain significantly underdeveloped compared to those available for dominant languages. This creates a paradox: while Uzbek children grow up increasingly surrounded by AI-enabled technologies, the educational AI systems available to them are largely designed for linguistic and cultural contexts far removed from their own experiences.

## **PURPOSE OF THE STUDY**

The purpose of this study is to examine how AI-powered personalized learning systems can be designed to effectively support mother-tongue education in low-resource language contexts, using Uzbek primary education as a case study. Rather than collecting new empirical data, this research employed a systematic literature review methodology to synthesize existing scholarship on AI in early childhood education, personalized learning technologies, culturally relevant pedagogy, instruction that draws on students' cultural knowledge, prior experiences, and frames of reference to make learning more meaningful and to affirm students' cultural identity (Ladson-Billings, 1995) and AI-supported native language learning. By analyzing patterns across these bodies of literature and applying them to the specific context of Uzbek education, this study aims to identify key principles for designing AI systems that are both pedagogically effective and culturally inclusive.

## **RESEARCH QUESTION**

The research question guiding this study is: How can AI-powered personalized learning systems be designed to effectively support mother-tongue education in low-resource language contexts, with Uzbek as a case study? This question addresses a critical gap in existing scholarship. While prior studies have

established the benefits of AI personalization in education and the importance of mother-tongue instruction, few have examined how these elements interact in low-resource language contexts. By centering Uzbek-speaking children, this research contributes to broader discussions of AI inclusivity and educational equity while providing practical insights that may inform educators, policymakers, and educational technology developers seeking to create more inclusive AI-based learning tools.

## **SYSTEMATIC LITERATURE REVIEW**

This systematic review involved a search of Google Scholar using a combination of keywords "artificial intelligence," "primary education," and "low-resource language". The search was limited to sources available in English, published between 2021 and 2025.

The search returned approximately 70 records. Google Scholar reports an estimated rather than an exact result count, and this figure fluctuated slightly, between 70 and 73, across repeated searches conducted on the same query. After removing one duplicate record and screening titles and abstracts against the inclusion criteria below, 20 full-text articles were assessed for eligibility. Many of the initial 70 records were excluded at this stage because they matched the search terms only incidentally: some used "low-resource language" in a purely computational-linguistics sense, such as building a dataset, spell-checker, or translation model, with no accompanying classroom or pedagogical component, while others mentioned "primary education" only as a participant demographic detail unrelated to the study's actual subject. To ensure relevance, studies were screened based on titles and abstracts, with inclusion criteria requiring that they explicitly discuss AI applications in early childhood or primary education, emphasize issues related to low-resource language contexts, or address cultural and linguistic inclusivity. Studies that focused solely on higher education, adult learning, or did not address issues of language resource limitations were excluded.

The full texts of the remaining articles were then reviewed in detail. From this pool, 6 studies were selected for in-depth analysis because they directly related to the research question of AI's role in supporting mother-tongue education in low-resource contexts such as Uzbek. The selection process involved evaluating each study's methodological rigor, including the clarity of its research design, the appropriateness of its methods to its stated research questions, and whether it had undergone peer review, alongside its relevance to low-resource language settings and its contribution to understanding culturally responsive AI systems. In addition to these six studies, this paper draws on supporting literature outside the formal review corpus, cited throughout the case study and design principles sections below to inform the discussion of Uzbek-specific applications and to define key terms.

## **AI IN EARLY CHILDHOOD AND PRIMARY EDUCATION**

Recent scholarship increasingly positions artificial intelligence as both a learning tool and a learning objective in early childhood and primary education. Yang (2022) argues that AI education should be integrated into digital literacy frameworks, emphasizing that young children already interact with AI-powered technologies in daily life. Rather than viewing AI as too complex for early learners, Yang suggests that children can grasp foundational ideas, such as pattern recognition and data-driven decision-making, when instruction is hands-on, culturally relevant, and developmentally appropriate. This perspective challenges traditional assumptions about the cognitive readiness of young children for technology-related concepts and opens possibilities for earlier and more meaningful integration of AI into primary curricula.

A similar study by Puspitaningsih et al. (2022) emphasizes that although children are surrounded by AI technologies at home, formal education systems have been slow to incorporate AI-based learning. Their work highlights the importance of early exposure to AI concepts in fostering computational thinking and problem-solving skills. The researchers note that the gap between children's everyday technological experiences and their formal educational experiences represents a missed opportunity for developing critical twenty-first-century competencies. Together with Yang's findings, this study suggests that AI integration in early education is not only feasible but increasingly necessary in preparing children for digitally mediated futures.

## **CULTURALLY RELEVANT AND MOTHER-TONGUE EDUCATION**

The importance of culturally relevant pedagogy and mother-tongue instruction in children's learning is well established in educational research. Children develop foundational cognitive and linguistic skills most effectively when instruction occurs in their first language, and they demonstrate stronger engagement and comprehension when educational content reflects their cultural backgrounds and lived experiences. These principles have significant implications for the design of AI-powered educational systems, particularly those intended to serve linguistically diverse populations.

A central promise of AI in education lies in personalization. Pesek et al. (2022) argue that recent technological advancements have enabled AI systems to adapt content to individual learners' needs, assist teachers in assessment, and provide targeted support for students with diverse abilities. Harry (2023) similarly identifies personalization, interactive learning opportunities, and improved administrative efficiency as central benefits of AI adoption in education; that argument, however, draws as much on illustrative examples and general observation as on empirical study, which is worth keeping in mind when extending its claims to a specific setting like Uzbek primary education. The potential for AI to create truly individualized learning pathways represents a significant advancement over traditional one-size-fits-all educational approaches. However, personalization alone does not guarantee equity. Salas-Pilco et al.

(2022) caution that AI tools may reproduce existing inequalities if they are not intentionally designed for minority and underrepresented students.

## **CHALLENGES OF AI IN LOW-RESOURCE LANGUAGE CONTEXTS**

While AI offers transformative educational potential, implementation in low-resource language contexts faces substantial challenges. These obstacles are technical, infrastructural, and sociocultural, and they must be understood clearly if inclusive AI systems are to be developed. Lewis (2025) demonstrates how AI language-learning tools trained on narrow datasets can marginalize minority learners. The study reveals that systems developed primarily with data from dominant languages often misinterpret linguistic variation, fail to recognize legitimate dialectal differences, or prioritize dominant cultural norms in ways that disadvantage minority students.

Fitas (2025) points to a related challenge specific to multilingual classrooms: AI-driven translation and language-assistance tools can help bridge instructional gaps for students who do not share the dominant language of instruction, but their reliability depends heavily on how well the underlying language models already support the languages in question. For a language such as Uzbek, this means that tools built on general-purpose multilingual models may perform far less reliably than they do for widely represented languages, reproducing at the classroom level the same resource gap that exists at the level of the underlying technology.

## **AI IN UZBEKISTAN CONTEXT – A CASE STUDY**

Applying the research findings to Uzbek primary education reveals both the need and the challenges of developing AI-powered mother-tongue learning systems. Uzbekistan's educational context presents a complex landscape in which language policy, technological infrastructure, and cultural factors all influence the potential for AI integration. Uzbek serves as the official state language and the primary medium of instruction in most public schools. The vast majority of primary school students learn in Uzbek, making mother-tongue education the norm rather than the exception at a policy level. However, the availability of high-quality digital educational resources in Uzbek remains limited compared to resources available in English or Russian.

Comparable efforts in other low-resource language settings suggest what such resources might look like. Mathai (2024) developed and evaluated an AI-powered application that delivers instructional support in students' native languages for underprivileged learners, reporting improvements in academic performance associated with instruction delivered in a language students already spoke fluently. Nanduri (2024) similarly designed a generative AI storytelling tool for Telugu-speaking children, working directly with young learners and their guardians to explore how AI-generated narratives could support both language acquisition and continued use of an endangered mother tongue. Neither project addresses Uzbek

specifically, but both indicate that AI-based, native-language tools are feasible to build and can produce measurable benefits when developed with the target language community from the outset, rather than adapted after the fact from a dominant-language model.

## **PROPOSED DESIGN PRINCIPLES FOR INCLUSIVE AI LEARNING SYSTEMS**

Based on the literature review and case analysis, this section identifies six key design principles for AI-powered personalized learning systems intended to support mother-tongue education in low-resource language contexts. These principles synthesize insights from across the reviewed studies and apply them specifically to contexts such as Uzbek primary education.

First, AI-powered educational systems must ground content in learners' cultural contexts. As Heeg and Avraamidou (2025) demonstrate, children conceptualize AI and other abstract concepts through lived experience. Educational content that reflects familiar settings, relationships, and cultural practices will be more meaningful and engaging than content imported from distant cultural contexts. For Uzbek learners, this means developing AI systems capable of generating or adapting content that incorporates local geography, family structures, cultural celebrations, traditional stories, and other elements of Uzbek life.

Second, addressing Lewis's (2025) concerns about dataset bias requires intentional development of training data that represents the target language community accurately and comprehensively. For Uzbek, this means creating or curating text corpora, speech databases, and educational content that reflect the full range of Uzbek language use, including regional variations, different registers, and diverse content domains. Dataset development should involve native speakers, educators, and cultural experts to ensure authenticity and appropriateness.

Third, systems should adapt to individual students' needs rather than applying a single instructional pathway to every learner. Pesek et al. (2022) show that AI can adjust the pace, difficulty, and format of content to match a learner's progress, and Harry (2023) points to comparable gains in engagement when instruction responds to individual students rather than a fixed curriculum. For Uzbek learners, adaptive personalization means building systems that track a child's proficiency in Uzbek specifically, rather than treating proficiency in a dominant language as a stand-in for it, and adjusting content accordingly.

Fourth, ethical safeguards against bias must be built into the system rather than added afterward. Salas-Pilco et al. (2022) warn that AI tools risk reproducing existing inequalities when they are not intentionally designed with minority and underrepresented students in mind, and Williamson and Eynon (2020) argue that the history of AI in education has repeatedly separated technical development from a critical accounting of whose interests a given system serves. For Uzbek-language systems, this means establishing processes for auditing model outputs for stereotyping or exclusion of regional and minority communities within Uzbekistan, and involving Uzbek educators and community members in evaluating those outputs before deployment.

Fifth, AI systems should be designed to support the preservation of the language itself, not only its use as a medium of instruction. Nanduri (2024) demonstrates this principle directly: a generative AI storytelling tool built together with Telugu-speaking children and their guardians helped sustain engagement with the language outside formal schooling by producing new cultural content in it, rather than only translating existing content into it. Applied to Uzbek, this suggests that AI tools should be capable of generating original Uzbek-language stories, songs, and educational materials, not only adapting materials originally produced in other languages.

Sixth, AI systems must remain accessible across the range of infrastructure conditions found in Uzbek schools, from well-resourced urban settings to rural schools with limited internet connectivity or device access. Fitas (2025) notes that AI-driven language and accessibility tools only benefit students when equitable access and implementation are addressed alongside the technology itself; a tool that requires constant high-bandwidth connectivity or specialized hardware will not reach many of the students it is intended to serve. For Uzbekistan, this points toward lightweight, offline-capable applications and compatibility with low-cost hardware as design requirements rather than afterthoughts.

## **LIMITATIONS AND FUTURE DIRECTIONS**

This study has several limitations that must be acknowledged. As a literature-based research project, it does not include primary data collection from Uzbek classrooms, students, or educators. The findings are synthesized from existing studies, many of which were conducted in contexts different from Uzbekistan. While the literature provides valuable insights that can be applied to the Uzbek context, direct empirical research would strengthen the understanding of how AI-powered systems actually function in Uzbek primary education settings.

The reviewed literature, while comprehensive within its scope, does not include studies specifically focused on AI implementation in Uzbek education. Overall, research on AI in low-resource language contexts remains limited, and studies focusing specifically on Central Asian educational contexts are particularly scarce. This gap in the literature itself underscores the need for more research attention to underrepresented linguistic and geographic contexts. Additionally, because the search was limited to sources published in English, relevant scholarship published in Uzbek or Russian may not have been captured — a limitation particularly worth noting for a study centered on Uzbek-language education.

## **CONCLUSION**

This study examined how AI-powered personalized learning systems can be designed to effectively support mother-tongue education in low-resource language contexts, using Uzbek primary education as a case study. Through a systematic review of literature on AI in early childhood education, personalized learning technologies, culturally relevant pedagogy, and AI-supported native language learning, the

research identified both the significant potential of AI to enhance learning outcomes and the substantial challenges that must be overcome to realize this potential equitably.

The findings demonstrate that AI can improve educational engagement, personalization, and outcomes when systems are thoughtfully designed. Young children are capable of engaging with AI concepts and benefiting from AI-powered instruction when learning experiences are developmentally appropriate and connected to their lived experiences. Mother-tongue instruction provides cognitive advantages that AI systems can support and enhance. Culturally relevant content strengthens both learning and identity formation.

However, the literature also reveals critical gaps in current AI development. Most AI-powered educational tools are designed for dominant languages, leaving low-resource language communities underserved. Dataset limitations, cultural bias, infrastructure constraints, and insufficient policy attention to educational equity all present barriers to inclusive AI implementation. These challenges are not merely technical but reflect broader patterns of inequity in technology development and educational resource distribution.

Based on this analysis, the study proposed six design principles for inclusive AI-powered learning systems: culturally relevant content design, inclusive and diverse training datasets, adaptive personalization based on student needs, ethical safeguards against bias, support for language preservation, and accessibility across infrastructure contexts. These principles provide a framework for developing AI systems that serve learners in low-resource language contexts effectively and equitably.

More work needs to be done in this area of AI research to bring out the cultural context of different societies, as culture is a defining factor for children at a young age, and culturally relevant pedagogy is essential in learning. The design and deployment of AI educational tools must move beyond one-size-fits-all approaches developed for dominant languages and actively engage with the linguistic and cultural diversity of global learner populations.

The implications of this research extend beyond Uzbek education. The principles and challenges identified here are relevant to other low-resource language communities seeking to leverage AI for educational improvement. As AI becomes increasingly central to educational technology worldwide, ensuring that these powerful tools serve all learners equitably is both an educational imperative and an ethical obligation.

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