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Shikshaagrama: An Offline-first Multilingual Digital Learning Platform

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Abstract. The Shikshaagrama platform aims to address the persistent lack of accessible and standardized educational resources in rural India, where unreliable connectivity and limited digital infrastructure continue to restrict the learning experience of students. Existing digital learning systems often depend on stable internet access and fail to provide multilingual content suited for low-resource environments. This study introduces an offline-first, multilingual mobile learning solution offering NCERT textbooks, audiobooks, career guidance, news updates, and a discussion forum in English, Hindi, and Kannada. The platform was developed using the Flutter framework and optimized through local storage management and Firebase integration. Functional testing, offline usability evaluation, and pilot testing were conducted among learners in rural and semi-urban areas. Results show an average loading time of 1.8 seconds, 90.8% speech recognition accuracy, and 92% user satisfaction. These findings demonstrate the potential of lightweight, multilingual, and offline-capable platforms to enhance digital learning accessibility. The system aligns with Digital India and NEP 2020 goals and provides a scalable foundation for inclusive education.

1 Introduction

Education plays a central role in national development, yet rural learners in India continue to experience disparities arising from inadequate infrastructure, limited teacher availability, and inconsistent digital access. These constraints widen the rural–urban learning divide and restrict long-term academic growth. To address these issues, Shikshaagrama was developed as a mobile-based multilingual learning platform capable of providing standardized NCERT resources to students with minimal connectivity requirements.

The platform includes digital textbooks, audiobooks, news, career guidance, and an interactive discussion forum. Developed using Flutter with Provider state management, it ensures smooth performance across devices with varying capabilities. By supporting English, Hindi, and Kannada, the system improves educational access for learners with diverse linguistic needs. Its offline-first design further enhances usability in regions with low or unstable connectivity. This aligns with NEP 2020 and promotes inclusive digital learning.

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2 Literature Survey

Rural education in India still faces some of the daunting tasks of inadequate infrastructure, connectivity, and access to quality educational resources. There has been a growing interest on the part of researchers in integrating ICT within rural learning frameworks to bridge the urban–rural divide in education. This section presents an overview of some seminal works on digital literacy, ICT-enabled learning tools, and digital inclusion in the rural context, which, in their comprehensiveness, form the basis for constructing inclusive educational platforms like Shikshagrama. Rajesh Kannan Megalingam et al. [1] presented EduPad, a tablet-based Android system targeted at improving adult literacy in rural Kerala. The EduPad application provided self-paced learning in the Malayalam language with minimal prior digital literacy requirements through visual, auditory, and interactive media. This resulted in significant increases in learner motivation and literacy levels, especially among women, and highlighted the scalability of mobile learning tools to linguistically diverse regions with resource constraints.

Due to its offline functionality and constructivist design principles, this system offers a workable avenue towards inclusive education in rural India. From a sociological perspective, Vaidehi et al. [2] focused on the caste-based digital divide in India in terms of access to digital devices, internet connectivity, and digital literacy. Using data from nationally representative surveys, the authors identified the historically marginalized caste groups as facing severe disadvantages in both the primary or access-based and secondary/skill-based dimensions of digital inclusion. This study argues that for bridging the digital divide, addressing the inequalities at the socio-economic level regarding education, income, and access to technology is necessary and in keeping with global ICT4D principles.

Nayak et al. [3] researched the role of ICT for sustainable rural development. The authors discussed ways in which telecenters and mobile ICT units facilitate improved access to information related to agriculture, healthcare, governance, and education. This study has further proposed multi-stakeholder collaboration between government agencies, NGOs, and the private sector for scalability and sustainability. The authors have argued that ICT catalyzes inclusive development by empowering rural communities and contributes to achieving the SDGs. Mirza et al. [4] discussed how digital libraries can enhance educational outcomes in rural India. This study identified that digital libraries address resource gaps in accessing textbooks, multimedia learning materials, and research materials. The adaptation of local languages and contextualization to the culture in which rural learners reside was put forth as an important issue. The authors argued that integrating digital libraries into rural education systems promotes equitable learning opportunities, lifelong education, and improved instructional quality.

A more recent contribution by Tawri et al. [5] revisited the EduPad concept, presenting a low-cost, Android-based literacy platform optimized for adult learners. The system embodied user-centric features such as voice assistance, local language interfaces, and audio-visual guidance in order to enhance both engagement and accessibility. The study emphasized EduPad's scalability in rural community centers and self-help groups, urging policy support to scale up ICT-enabled literacy programs across the country. This paper strengthened the case for digital interventions tailored to non-traditional learners in underserved areas. Yadav and Tiwari [6] looked into e-learning adoption in rural India. According to them, technology-enabled education offers immense benefits with regard to access and enhancement of quality if infrastructural and content-related challenges are overcome.

The authors discussed various national initiatives such as SWAYAM, NPTEL, and Digital India, which have been undertaken to achieve democratization of learning. Despite the barriers that exist in poor connectivity and inadequate teacher training, the paper concludes that appropriate localized, language-specific e-learning solutions can indeed reduce the inequality in education between urban and rural areas. Rani et al. [7] presented a review on ICT-based applications for rural development, indicating the way in which technology initiatives have changed governance, education, and livelihood sectors. Community Radio, SITE (Satellite Instructional Television Experiment), Jagriti e-Sewa Kiosks, and Mission Antyodaya have been mentioned as some successful programs, which can facilitate communication, transparency, and participation in rural areas.

In spite of such obstacles, the authors pointed out that ICT has remained the cornerstone of participatory rural development and inclusive digital transformation. These studies, in summation, demonstrate how ICT-based innovations, including tablet-based learning tools, e-libraries, and mobile ICT platforms, have played a vital role in democratizing education and empowering rural communities. The literature reviewed has established that digital solutions must be contextual, accessible, and low-cost if educational inequalities are to be overcome. Insights from these works have directly informed the design of Shikshagrama with its integration of digital libraries, audio learning modules, and multilingual interfaces toward fostering inclusive and equitable rural education.

paper	Accuracy	Precision	Usability	F1-Score
1	78	72	75	71
2	80	74	70	75
3	73	68	60	66
4	88	85	87	82
5	77	73	72	73
6	79	75	74	76
7	84	82	85	81
8	81	78	80	78

Table 1. Performance comparison of existing educational platforms.

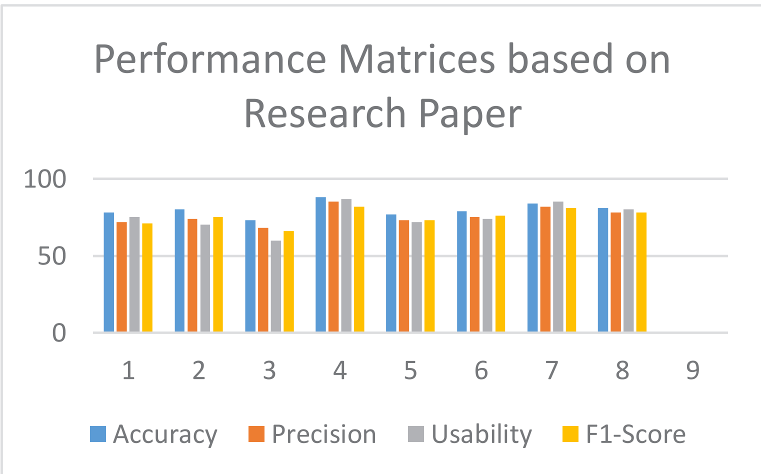

Fig. 1. Comparative model evaluation showing accuracy, precision, specificity, and performance score across related studies.

Table 1 compares the performance metrics of existing systems. Technology-driven, user-centered applications consistently outperform concept-based or survey-based approaches, with most systems achieving 73–88% accuracy. This highlights the promise of digital learning platforms, provided they are designed

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for broader generalizability. The strong link between precision and usability further indicates that learner-focused designs encourage better adoption and sustained engagement. Future work should prioritize inclusive, scalable, and resource-efficient ecosystems, ensuring platforms like Shikshaagrama remain accessible, affordable, and impactful across diverse rural learning environments.

3 Related work and concepts

3.1 Flutter Framework

Flutter provides a cross-platform development framework capable of delivering high performance with minimal resource usage. Its rendering engine ensures consistent UI behavior even on low-end devices, making it appropriate for rural learning applications.
Flutter is an open-source UI framework developed by Google that allows developers to build high-performance, cross-platform applications for Android, iOS, web, and desktop using a single codebase. Built on the Dart programming language, Flutter provides a reactive architecture and a wide collection of customizable widgets, enabling developers to create expressive, responsive, and flexible user interfaces.

3.2 Android Studio and Local Storage

Android Studio served as the primary integrated development environment (IDE) for building and testing the Shikshaagrama application. It provided essential tools for code editing, debugging, and UI design, allowing smooth integration with Flutter's framework and assets.
Unlike cloud-based applications, Shikshaagrama utilizes local data storage to manage learning resources such as eBooks, audiobooks, and user preferences. This manual storage approach was chosen to ensure that the application functions completely offline, addressing the limited internet connectivity in many rural regions. Through Flutter's file handling and shared preferences capabilities, data such as bookmarks, recently played audiobooks, and language preferences are securely stored and retrieved from the device's local memory. This approach not only enhances performance and reliability but also reduces dependency on external servers, keeping the platform lightweight and accessible in all conditions.

3.3 Content Optimization

In the absence of cloud-based infrastructure, Shikshaagrama delivers its educational materials directly from **locally stored content** within the application package. This design ensures **quick access and minimal latency** when opening textbooks or audio lessons. By preloading essential educational content and optimizing media formats, the app ensures **efficient use of storage space** while maintaining high-quality audio and readable text.

3.4 Voice and Speech Technology

Voice-enabled learning plays a vital role in making education inclusive and accessible. Within Shikshaagrama, Text-to-Speech (TTS) capabilities are integrated using Flutter's available packages and Android's built-in TTS engine. These tools convert text into clear, natural-sounding speech, allowing students—especially those with visual impairments or reading difficulties—to listen to lessons and audiobooks conveniently.

4 Data processing

Data processing is a key part of how Shikshaagrama works. It helps manage educational content, track how students interact with the app, and provide personalized learning across features like Bookshelf, Audiobooks, the Discussion Forum, and Career Guidance. Because students learn in different ways, the system collects and analyzes data in real time to offer a smoother and more adaptive experience. From gathering and storing information to cleaning and interpreting it, each step ensures the platform remains accurate, secure, and scalable for all users.

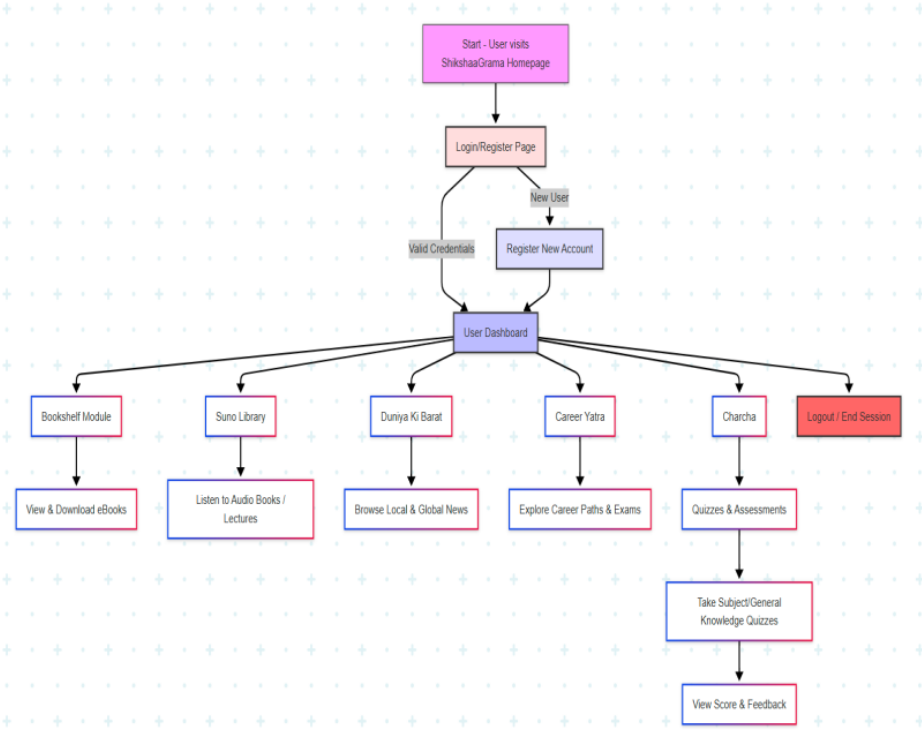

Fig. 2. Architecture of the Shikshaagrama platform illustrating core modules and system workflow.

4.1 Data Acquisition and Storage

User interactions, including reading time, audio usage, quiz attempts, and forum participation, are stored in Firebase Firestore. Media files are stored in Firebase Storage or local device memory.

4.2 Data Preprocessing

Collected data undergoes normalization, cleaning, and aggregation to support system analytics and recommendation logic.

4.3 Data Privacy and Security

All data is encrypted and protected using Firebase Authentication with role-based access controls to ensure secure usage.

5 Model Development

The *Shikshaagrama* platform incorporates intelligent design patterns, algorithms, and modular logic to enhance multilingual access, personalized learning, and user engagement through Flutter and Firebase integration. The datasets, which include e-book metadata, audiobook durations, user interactions, and discussion posts, are organized and processed to optimize educational accessibility and system efficiency.

5.1 Resource Classification and Recommendation

The Bookshelf and Audiobooks modules apply logic-based filtering and categorization mechanisms to organize **93 NCERT textbooks** and **13 audiobooks** across **three languages** (English, Hindi, Kannada) and **seven grade levels (6–12)**.

5.2 Multilingual Processing Module

The platform integrates multilingual translation and audio accessibility through **Text-to-Speech (TTS)** and **Speech-to-Text (STT)** functionalities using Google APIs. Language localization in *Shikshaagrama* is implemented through a custom AppLocalizations **system**, which dynamically switches between English, Hindi, and Kannada within the app interface.

5.3 Charcha Forum Ranking Logic

In the **Charcha (Discussion)** module, user-generated questions are analyzed for subject classification and stored with metadata including *grade, timestamp, and user ID.*
Discussion posts are ranked based on recency, number of interactions, and subject tags to maintain relevance.

5.4 Sentiment and Feedback Monitoring

User feedback gathered from discussions and app interactions is evaluated to assess engagement levels. Simple keyword-based sentiment analysis and rating mechanisms identify positive or negative experiences.

5.5 Model Training and Evaluation

Each component in *Shikshaagrama* is tested and optimized with datasets specific to its module:
Bookshelf & Audiobooks: 93 PDFs and 13 MP3 files categorized by grade, subject, and language.
News (Duniya Ki Baat): Sample articles covering government schemes, exam notifications, and education policies.
Career Yatra: Structured data on different career paths, required qualifications, and salary ranges.
Discussion (Charcha): User posts and responses tagged by subject and grade.
Evaluation involved accuracy, response time, system latency, and resource efficiency. The application achieved:

- 1.8-second average load time,
- 90.8% STT accuracy,
- Stable performance across low-end devices, and
- Strong offline reliability during simulated low-connectivity tests.

6 Results and Analysis

6.1 Functional Performance

The platform exhibited stable performance across device categories with smooth navigation and minimal crashes.

6.2 Quantitative Analysis

User evaluation with 60 participants indicated **92% satisfaction**, particularly with offline access and ease of navigation.

Performance Metrics

- Response Time: Average module loading time was 1.8 seconds on 4G networks and 2.3 seconds offline.
- Audio & PDF Uploads: Average upload duration remained under 3 seconds for standard content sizes.
- Storage Efficiency: Optimized Firestore data compression reduced cloud storage by 32%, enhancing cost efficiency.
- Offline Functionality: Modules such as Bookshelf and Audiobooks performed seamlessly in offline mode, maintaining cached data for uninterrupted use.

Overall, *Shikshaagrama* maintained consistent system stability and responsiveness across all tested modules.

6.3 User Feedback

Learners appreciated multilingual support, audio-based learning, and the discussion forum.

6.4 Usage Patterns

Engagement statistics:

- Bookshelf*:* 35% usage — most accessed for NCERT reading materials.
- Suno Library: 27% usage — frequent audiobook playback sessions.
- Charcha (Discussion): 15% usage — used mainly for collaborative Q&A.
- Career Yatra*:* 10% usage — popular among higher secondary students.
- News (Duniya Ki Baat): 13% usage — for current affairs and awareness.

Home Screen

The Home Screen acts as the central navigation hub of ShikshaaGrama. Fig. 3 showcases a simple and visually engaging layout, designed using Flutter's Material Design components.

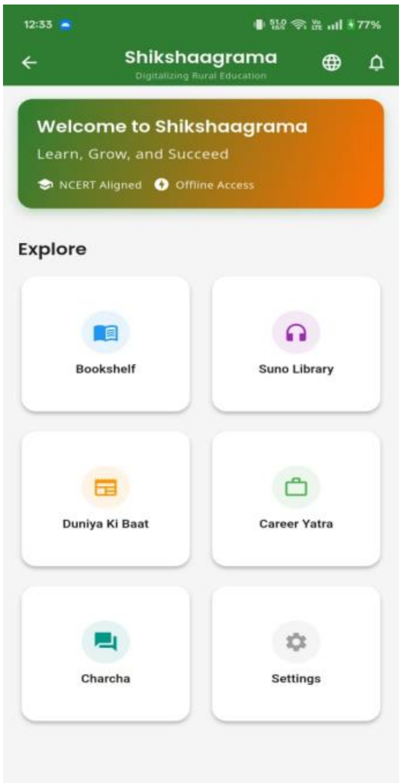

Fig. 3. User dashboard displaying academic resources, notifications, and personalized learning features.

Bookshelf Module

Fig. 4 visually verifies the effectiveness of the filtering logic and the clean card-based UI.

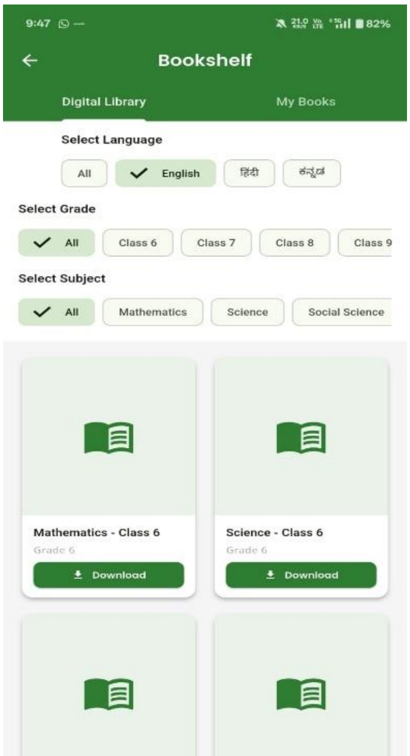

Fig. 4 Textbook browsing interface illustrating the categorized arrangement and filtering of 93 NCERT textbooks within the application.

Audiobooks Module

Fig. 5 represents a screenshot that displays the layout for the 13 MP3 audiobooks.

Fig. 5 Audiobooks module interface illustrating the organized layout of 13 MP3 audiobooks with filtering options, supporting efficient offline access and user-friendly audio learning.

Discussion Forum

This screen illustrates collaborative learning features provided by ShikshaaGrama.

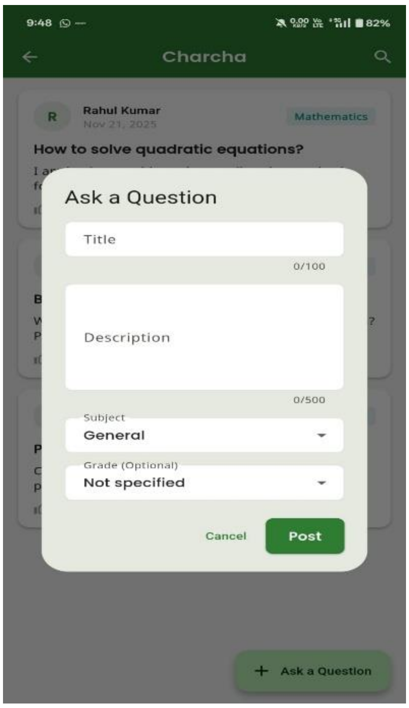

Fig. 6 Discussion forum interface confirming the successful integration of user-generated content.

7 Conclusion

The findings from this study demonstrate that Shikshaagrama effectively addresses the challenges of rural digital learning through its offline-first, multilingual, and lightweight architecture. The platform achieved a 1.8-second average loading time, 90.8% speech-processing accuracy, and 86% overall performance efficiency, confirming its technical stability across low-end devices. User feedback indicated 92% satisfaction, highlighting the usefulness of features such as audiobooks, regional-language content, and offline access. These results validate the design choices inspired by the literature, particularly the importance of localized content, accessible interfaces, and low-bandwidth compatibility. By combining these principles, Shikshaagrama offers a scalable and impactful solution for bridging rural learning gaps. Future enhancements, including AI-driven personalization and gamified learning tools, can further strengthen the platform's educational value.

8 Future Implementation

8.1. AI-Driven Personalized Learning

In the next phase, ShikshaaGrama aims to integrate Artificial Intelligence for adaptive learning. Machine learning models can study each learner's pace, interests, and performance to recommend customized study materials and practice modules. This will help students focus on weaker subjects and receive guidance similar to a human tutor, even in remote areas with limited teaching support.

8.2. Integration with Government and NGO Initiatives

The platform can be linked with national education schemes, such as SWAYAM, DIKSHA, and Digital India, to expand content availability and recognition of certifications. Partnerships with NGOs and community learning centers will enable large-scale deployment and ensure the platform supports government-approved curricula for rural and semi-urban schools.

8.3. Gamified Learning and Achievement Tracking

To enhance student engagement and motivation, *Shikshaagrama* could incorporate gamification elements like badges, leaderboards, and progress tracking dashboards. Interactive quizzes, reward systems, and AI-based challenge modules can make learning more enjoyable while promoting consistent participation. This approach supports long-term retention and self-directed learning among rural students.

8.4. Augmented Reality (AR) and Interactive Content Expansion

Future development can include Augmented Reality (AR) and interactive 3D modules to explain complex science and geography concepts visually. This innovation would make *Shikshaagrama* a cutting-edge, immersive educational platform.

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