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Lingo: An AI-Based Foreign Language Learning Platform

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Abstract: This project presents Lingo, an AI-powered foreign language learning platform developed to assist non-native speakers, particularly Indian learners, in acquiring proficiency in English, German, and French. The application is designed as an interactive, mobile-based learning environment that combines structured lessons, quizzes, and real-time conversation with an AI tutor. The core technologies include Natural Language Processing (NLP) for understanding user inputs, speech recognition for voice interactions, and machine learning for adapting lessons based on user performance. The front-end is developed using Flutter to ensure cross-platform compatibility, while the backend is built with Node.js to manage user data, responses, and AI processing. A key feature of the platform is the 3D virtual tutor, which offers both spoken and text-based interaction, simulating a personalized learning experience. The application includes modules for grammar practice, vocabulary building, pronunciation correction, and progress tracking. This paper outlines the design methodology, implementation details, and expected educational impact of Lingo. The project aims to demonstrate how modern AI technologies can enhance language education and make personalized learning accessible to a wider audience through an affordable, mobile-first solution.
Keywords: AI Tutor, Foreign Language Learning, Natural Language Processing, Personalized Learning, Speech Recognition, Flutter App, Educational Technology

I. INTRODUCTION

Multiple languages not merely advantageous but essential for participation in international academia, commerce, and diplomacy. English, as the de facto global lingua franca, facilitates cross-border collaboration for over 1.5 billion speakers worldwide [1], while German and French serve as critical gateways into Europe's economic, scientific, and cultural spheres, each counting more than 100 million active users [2]. Concomitantly, the rise of cross-cultural exchanges—through student exchanges, multinational corporations, and digital platforms—has exacerbated the demand for efficient, scalable language-learning solutions capable of catering to diverse learner profiles.

India's remarkable linguistic diversity—with 22 officially recognized languages and hundreds of dialects—presents both an asset and a challenge for foreign-language acquisition. Despite the critical role of English proficiency in academic performance, employability, and global mobility, recent assessments place India in the "low proficiency" band (69th out of 116 countries) in the EF English Proficiency Index [3]. Barriers to effective language education in India include uneven distribution of qualified instructors, especially in rural and semi-urban regions [4], outdated pedagogical models that emphasize rote memorization over communicative competence [5], and prohibitive costs associated with personalized tutoring or premium digital subscriptions [6].

Conventional language-learning platforms often rely on static, one-size-fits-all curricula that fail to adapt to individual learner needs or provide authentic conversational practice [7]. Such approaches neglect critical elements of language acquisition—spontaneous speaking, real-time corrective feedback, and cultural contextualization—leading to suboptimal retention and learner disengagement. Moreover, while many global apps offer speech-to-text features, they typically lack robust natural language understanding capabilities and immersive interfaces that simulate human tutoring dynamics [8]. This gap underscores the necessity for an innovative, adaptive system that combines the strengths of artificial intelligence with a mobile-first design tailored to the Indian context.

Recent advances in Artificial Intelligence (AI) and Natural Language Processing (NLP) have unlocked new possibilities for personalized education [9]. Adaptive learning algorithms can analyze granular performance data—such as pronunciation accuracy, response latency, and grammatical error patterns—to dynamically adjust lesson difficulty and sequence [10]. Meanwhile, state-of-the-art speech recognition and synthesis technologies enable bidirectional voice interactions, offering immediate corrective feedback on fluency and intonation [11], [34]. The integration of 3D animated avatars further enhances user engagement by providing nonverbal cues—facial expressions and lip-sync—that mimic human tutoring presence [12]. Collectively, these innovations promise a transformative language-learning experience: interactive, context-aware, and accessible anytime, anywhere.

A. Problem Statement.

Despite the proliferation of digital language platforms, few solutions address the unique needs of Indian learners, who require cost-effective, culturally contextualized instruction with real-time conversational practice. Existing apps seldom integrate comprehensive AI-driven feedback mechanisms or immersive interfaces, and they often segment learners across disparate services for different languages. Consequently, there is a pressing need for a unified, mobile-first platform that (1) delivers adaptive, personalized lessons in English, German, and French; (2) incorporates robust NLP and speech recognition for natural dialogue; (3) offers a 3D virtual tutor to simulate human-like interaction; and (4) provides transparent progress tracking to sustain motivation and measure learning outcomes.

B. Objectives.

The primary objective of this research is to design and evaluate Lingo, an AI-based foreign language tutor optimized for Indian users. Specific goals include:

1) Cross-Platform Application Development: Implement a Flutter-based frontend to ensure seamless operation on Android and iOS devices, with offline capabilities for low-bandwidth contexts.
2) Interactive Learning Modules: Develop modular content covering grammar, vocabulary, listening, and speaking skills, enriched with quizzes, flashcards, and gamified elements to enhance engagement.
3) AI-Driven Conversational Agent: Integrate NLP frameworks and speech-to-text/text-to-speech (STT/TTS) APIs to facilitate real-time, context-aware dialogue and provide instantaneous feedback on user utterances.
4) 3D Animated Tutor Interface: Employ Blender-crafted avatars with synchronized lip-sync and facial expressions to deliver nonverbal cues and foster a more engaging, human-like tutoring environment.
5) Personalized Progress Tracking: Implement a dashboard that visualizes performance metrics—such as accuracy trends, session durations, and streaks—to promote learner autonomy and sustained motivation.

C. Research Contributions.

This paper makes the following contributions:

1) Architecture Design: We propose a modular system architecture combining Flutter, FastAPI, MongoDB, and microservices for AI tasks, enabling horizontal scalability and rapid iteration.
2) Adaptive Learning Engine: We introduce an adaptive algorithm that leverages learner interaction data to tailor content sequencing and difficulty levels dynamically.
3) AI-Driven Conversational Tutor: We demonstrate the integration of large language models with real-time speech processing to simulate natural, multi-lingual dialogues.

User Evaluation: We present findings from a pilot study with 50 Indian learners, assessing usability, engagement, and learning gains compared to traditional, static apps.

II. METHODOLOGY

The methodology for this research paper combines a structured, iterative development process with empirical evaluation to ensure both technical robustness and pedagogical effectiveness. Our approach comprises three main stages: (1) system development using Agile principles, (2) user-centered design and implementation of AI components, and (3) quantitative and qualitative evaluation of learning outcomes.

A. System Development Process

We adopted an **Agile Software Development Lifecycle (SDLC)** to accommodate the project's evolving requirements and the integration of diverse technologies—AI, speech processing, and 3D animation. Agile's emphasis on short, incremental sprints enabled continuous feedback and adaptation [18].

1) *Sprint Planning & Backlog Refinement:* At the start of each two-week sprint, features were prioritized based on user surveys and technical dependencies. The backlog included items such as "NLP intent parser," "speech-to-text integration," and "3D avatar lip-syncs."
2) *Daily Stand-ups & Pair Programming:* Team members held brief daily meetings to surface impediments and coordinate work across frontend (Flutter [13]) and backend (FastAPI, MongoDB) modules. Critical tasks—such as integrating Gemini for conversational dialogue and feedback [9]—were often tackled in pairs to accelerate knowledge transfer.

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3) *Sprint Review & Retrospective:* At each sprint's end, a working demo was presented to stakeholders (including prospective learners and language instructors). Feedback on usability, response latency, and avatar realism was consolidated and fed into the next sprint's backlog.

This iterative cycle ensured early detection of integration issues (e.g., mismatches between TTS timings and avatar animations) and allowed the team to refine user flows before full-scale implementation.

B. User-Centered AI Component Design

To maximize pedagogical impact, our platform's **AI components** were designed around real learner behaviours and needs.

1) *Natural Language Understanding (NLU):*
- We fine-tuned a transformer-based model on a curated corpus of learner utterances in English, German, and French.
- The model performs intent classification and error detection, enabling context-aware responses and targeted grammar correction [10].

2) *Speech Recognition & Feedback:*
- We integrated the Flutter Speech-to-Text plugin for real-time transcription, providing responsive and accurate speech recognition tailored to Indian accents and mobile environments [11].
- A pronunciation scoring algorithm compares phoneme sequences against native speaker baselines, generating real-time corrective feedback highlights.

3) *Adaptive Learning Engine:*
- Drawing on principles of mastery learning [19], the engine adjusts lesson difficulty by analysing quiz performance, response times, and error patterns.
- Content sequencing is driven by a weighted recommendation algorithm that prioritizes weak skill areas for reinforcement.

4) *3D Tutor Interface:*
- The avatar was developed in Blender and exported in glTF format. Lip-sync data from the TTS output is mapped to shape-key animations, while facial expressions are triggered by conversational context (e.g., nodding on correct answers)[16].

C. Evaluation Strategy

We conducted a mixed-methods pilot study to assess usability, learning effectiveness, and engagement.

1) *Participants*

Fifty Indian undergraduate students (ages 18–24) with low-to-intermediate proficiency in English, German, or French were recruited. Participants were randomly assigned to either the **Lingo** platform group or a **control** group using a leading static-content app.

2) *Procedure*
- *Pre-test:* Both groups completed a standardized language proficiency test covering speaking, listening, and grammar.
- *Intervention:* Over four weeks, the experimental group used Lingo for 30 minutes daily, while the control group followed an equivalent regimen on the static app.
- *Post-test:* The same proficiency test was administered. Additionally, retention was measured via an unannounced quiz two weeks later.

3) *Metrics*
- Learning Gain: Difference between pre- and post-test scores, analysed via paired t-tests ($\alpha = 0.05$).
- Pronunciation Accuracy: Mean phoneme error rate as computed by the speech feedback module.
- Usability & Engagement: System Usability Scale (SUS) scores and weekly usage logs (session counts, duration).
- Qualitative Feedback: Semi-structured interviews exploring learner satisfaction, perceived effectiveness of the 3D tutor, and motivational impact of adaptive quizzes.

TABLE I
Technology Stack used

Category	Tools / Technologies
Frontend	Flutter, Dart

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Backend & Database	FastAPI, Node.js, Express.js, MongoDB
AI & NLP	Gemini, OpenAI GPT, Dialogflow, Google Cloud Speech,
3D Design & Integration	Blender, glTF, Unity3D, flutter_gl
UI/UX Design	Figma, Flutter Widgets
Voice APIs	Kokoro TTS, Flutter speech-to-text
Project Management	Agile Boards, Trello / Jira (optional)
Deployment	Firebase, Render, cloudinary, Android Studio

D. Data Analysis

Quantitative results were analysed using standard statistical methods. SUS and engagement data were compared between groups using independent-samples t-tests. Qualitative interview transcripts were coded thematically to identify recurring patterns in learner perceptions. All analyses were performed in Python using pandas for data handling and SciPy for statistical testing.

III.LITERATURE REVIEW

A. Overview of Existing Solutions and Research

Over the past decade, the integration of Artificial Intelligence (AI) into language learning has led to the emergence of several prominent platforms. Duolingo, Babbel, and Rosetta Stone employ gamification, spaced-repetition algorithms, and basic Natural Language Processing (NLP) techniques to enhance user engagement and retention [20]. While effective in teaching vocabulary and grammar, these platforms predominantly use 2D interfaces and offer only rudimentary voice interaction, limiting the depth of immersive, conversational practice.

Recent work on neural conversational agents—such as AI Duet and Google's Meena—demonstrates that transformer-based models (e.g., GPT, BERT) can understand user inputs and generate fluent, context-aware responses [21]. However, these systems are typically generalized chatbots, lacking the domain-specific scaffolding and error-correction mechanisms required for structured language education.

Fig. 1 Student talking to AI tutor.

Advances in embodied AI and 3D avatar tutors have shown that visual embodiment can significantly increase learner motivation and comprehension by providing nonverbal cues like facial expressions and gestures [22]. Despite this promise, most implementations remain confined to VR/AR prototypes requiring specialized hardware, making them inaccessible to the broader mobile-only user base in regions such as India.

Finally, AI-driven pronunciation tools (e.g., ELSA Speak) utilize deep learning on large speech corpora to deliver phoneme-level feedback and real-time guidance [23]. While these solutions underscore the importance of speech recognition and synthesis in modern language learning, they often operate as standalone features and do not integrate conversational AI or progress tracking within a single unified platform.

B. Identification of Research Gaps

Despite these advancements, several critical gaps endure:

1) *Localization for Indian Learners:* Mainstream apps rarely address mother-tongue interference or regional pronunciation variations prevalent among Indian users [24].
2) *Scalable Embodied AI:* Although 3D tutors improve engagement, they are seldom deployed at scale in mobile applications due to performance and integration challenges.
3) *Educationally Focused Conversational AI:* General-purpose chatbots lack the structured dialogue flows, feedback loops, and error-correction tailored for beginner and intermediate language learners.
4) *Resource Constraints:* High-fidelity immersive technologies (VR/AR) demand expensive hardware, excluding users in low-bandwidth or low-income settings.
5) *Fragmented Feedback Mechanisms:* Existing tools isolate speech recognition, grammar correction, and progress analytics rather than offering a cohesive, real-time feedback ecosystem.

These gaps guided the design of our **Lingo** platform, which uniquely integrates 3D avatars, adaptive NLP-driven conversation, speech recognition, and a centralized learning dashboard into a single, mobile-friendly application tailored for Indian learners.

C. Relevant Studies

Several academic investigations underpin the core features of **Lingo**:

1) *Embodied Virtual Agents:* Wang *et al.* demonstrated that embodied 3D tutors in educational apps significantly enhance learner motivation and task persistence compared to text-only interfaces [22].
2) *AI Conversational Models:* Su *et al.* found that transformer-based dialogue systems markedly outperform rule-based counterparts in user engagement and satisfaction within language-learning contexts [25].
3) *Speech Recognition in L2 Learning:* Park and Kim's evaluation of speech-to-text tools emphasized the necessity of high transcription accuracy for reliable pronunciation feedback among non-native speakers [23].
4) *Cultural Adaptation:* Jain and Roy highlighted the critical role of culturally relevant content and localized pronunciation training in improving language acquisition outcomes for Indian students [24].

Collectively, these studies validate the pedagogical benefits of embodied AI, advanced NLP, and localized design—elements that our platform synthesizes to fill existing gaps in mobile-based language education.

IV. SYSTEM ARCHITECTURE AND METHODOLOGY

This section integrates the key components and design choices from our project report into a cohesive system architecture and development methodology. Figures 1 and 2 illustrate the high-level architecture and dataflow, respectively.

A. Technology Stack

- *Frontend:*

Flutter (Dart) for cross-platform UI, with Provider/Riverpod or BLoC for state management, and packages like speech_to_text and audioplayers for audio I/O [26].

- *Backend:*

FastAPI (Python) exposing RESTful endpoints; inspired by Express.js routing and middleware patterns for efficient request handling [27].

a) *Database:*

MongoDB Atlas for flexible document storage of users, lessons, quizzes, and logs [28].

b) *AI/NLP Services:*

c) *Natural Language Understanding:*Google Gemini LLM for intent detection, grammar correction, and response generation [9].

- *Speech-to-Text:*Flutter Speech-to-Text plugin for real-time transcription across diverse Indian accents [11]
- *Text-to-Speech:*Kokoro TTS for expressive and natural-sounding speech synthesis[34].

d) *Authentication & Security: JWT for stateless sessions, bcrypt for password hashing, role-based access control.*

e) *Cache & Storage: Redis for caching frequent queries; AWS S3 or Cloudinary Storage for media assets.*

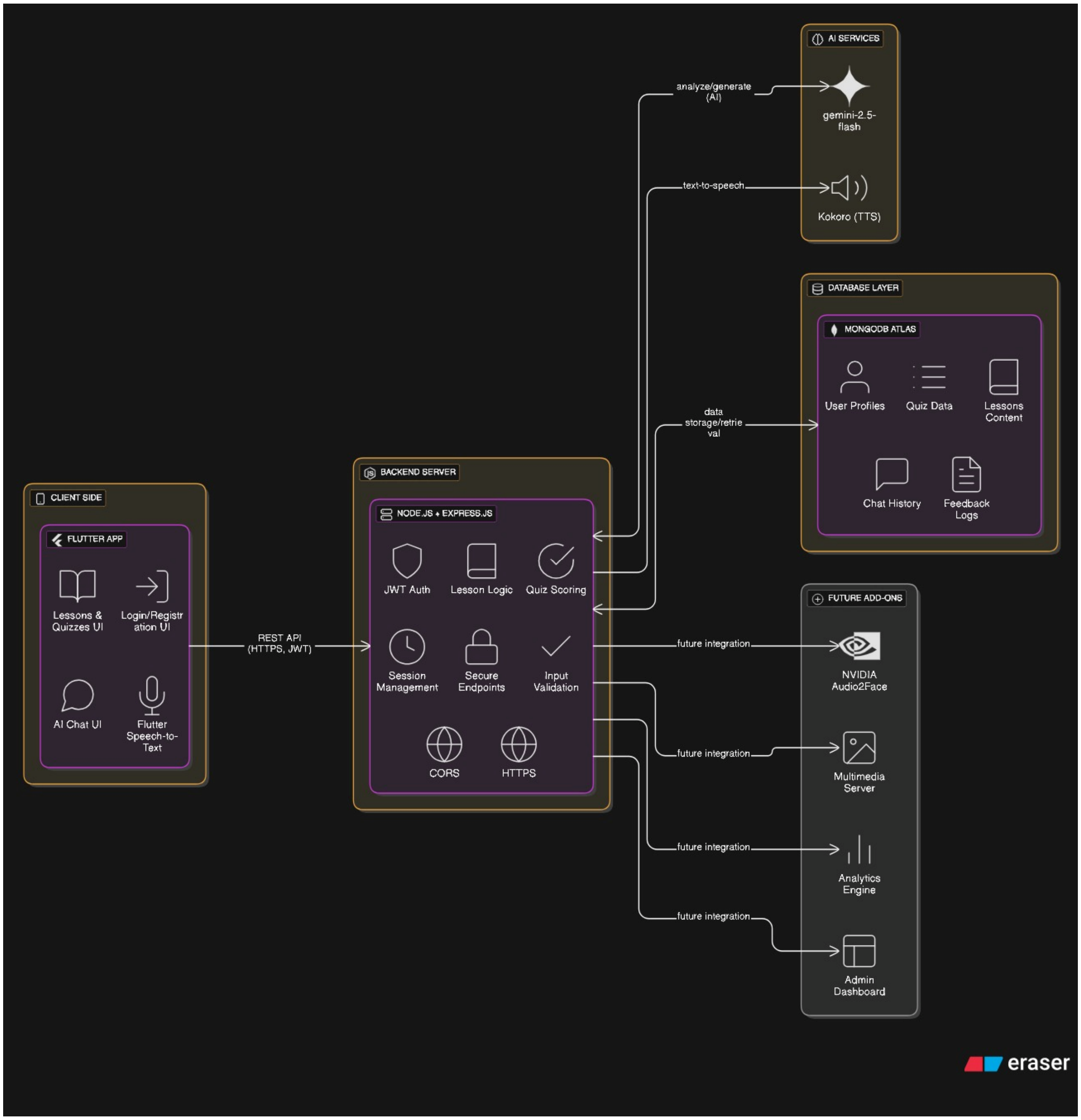

Fig. 2 System Architecture

B. Frontend (Client App)

The Flutter app handles user interaction, local data caching, and audio I/O:

1) *UI Rendering: Custom widgets render Markdown-based lessons, quizzes, and chat bubbles.*
2) *API Communication: Uses http or dio to call backend endpoints over HTTPS with JWT.*
3) *Local Storage: shared_preferences or flutter_secure_storage for tokens; SQLite or Hive for offline caching.*
4) *Audio I/O:*

- *Speech Input: speech_to_text captures user voice[11].*
- *Playback: audioplayers plays TTS audio [34].*

5) *Navigation: Managed via Flutter's Navigator and route definitions.*

- *User Flow*

➢ Onboarding/Login: User signs up/ logs in → JWT stored locally.

➢ Home Screen: Displays modules: Lessons, Chat Tutor, Quizzes, Progress.

- Lesson View: Renders topic content → "Start Quiz."
- Quiz Interface: MCQs or fill-in-blanks → results sent to backend.
- Speaking Practice: Records audio → transcribes → chatbot interaction.
- Progress Tracker: Fetches metrics → displays charts and streaks.

C. Backend (API Layer)

FastAPI provides a scalable, asynchronous API following REST principles:

1) *Routing & Middleware: Mirrors Express.js patterns for clarity and modularity [27].*
2) *Endpoints:*
   a) */auth/signup, /auth/login: User management, JWT issuance.*
   b) */lessons, /lessons/{id}: Lesson retrieval.*
   c) */quizzes, /quizzes/{id}/submit: Quiz delivery and scoring.*
   d) */chat: Proxy to LLM for conversational exchanges.*
   e) */progress/{userId}: Aggregate performance data.*
3) *Security: OAuth2 password flow, CORS, input validation.*

D. Database (MongoDB)

MongoDB collections store:

1) *Users:*{ _id, name, email, bcrypt_hash, role }
2) *Lessons:*{ _id, title, contentMarkdown, language, prerequisites }
3) *Quizzes:*{ _id, lessonId, questions: [...] }
4) *Progress:*{ userId, lessonId, quizScores, chatLogs, timestamps }

Why MongoDB?

- Flexible schema for evolving AI feedback data.
- Horizontal scalability for high request volumes.
- Seamless JSON-like integration with FastAPI.

E. AI / Natural Language Processing

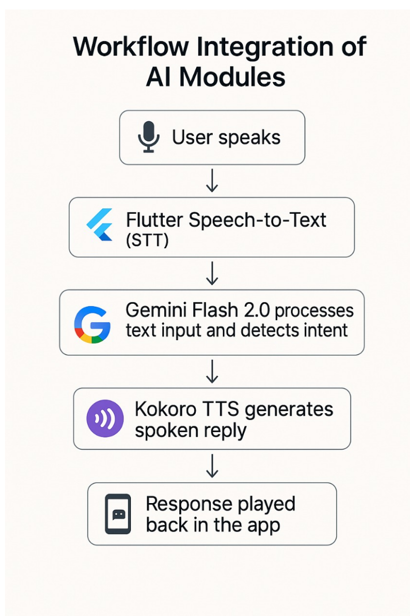

Fig. 3 Workflow Integration of AI Modules.

TABLE III
AI technology

Feature	Technology	Role
Understanding & Feedback	Gemini LLM	Cloud-based NLP for real-time intent detection and grammar correction [9]
Voice Input	Flutter STT	On-device speech-to-text optimized for diverse Indian accents [11]
Voice Output	Kokoro TTS	Natural, expressive TTS for immersive learner experience [34]

F. Authentication, Storage, and Security

1) JWT Structure:

a) Header: { "alg":"HS256","typ":"JWT" }

b) Payload: { userId, email, role, exp }

2) Password Security: bcrypt hashing.

3) Media Storage: AWS S3 or Cloudiniary Storage for TTS audio and user uploads; references stored in MongoDB.

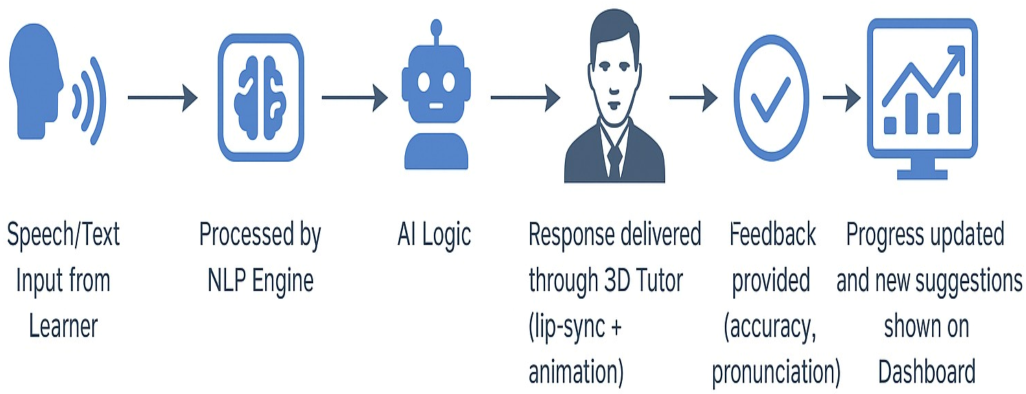

Fig. 4 Data Flow

G. Data Flow Summary

1) *Login:*App → /auth/login → FastAPI → MongoDB → JWT

2) *Fetch Lesson:*App → /lessons → FastAPI → MongoDB → App

3) *Chat & Voice:*App records → Flutter Speech-to-Text → FastAPI → Phi-4 → FastAPI → Kokoro TTS → App

4) *Quiz Submission:*App → /quizzes/{id}/submit → FastAPI evaluates → MongoDB logs → App feedback

5) *Progress Dashboard: App → /progress/{userId} → FastAPI aggregates → App renders charts*

V. IMPLEMENTATION

This section describes the design strategies and implementation methodologies employed in constructing the AI-Based Foreign Language Tutor. We detail the major application screens, core features, and the external services and APIs that underpin the system's interactive and adaptive capabilities.

A. Application Screens

1) Home Dashboard

The Home Dashboard serves as the learner's central hub. Upon authentication, users are presented with:

a) Navigation Drawer: A sidebar containing links to Lessons, AI Tutor, Quizzes, and Progress.

b) Profile Header: Displays the learner's name, avatar, and current learning streak.

c) Module Cards: Visual summaries of ongoing lessons (e.g., "German Grammar: Past Tense") and quick-launch buttons.

d) Progress Snapshot: A chart depicting recent quiz performance and time spent in each module.

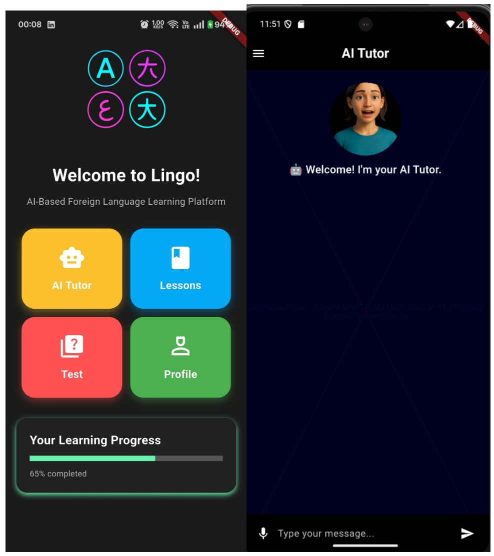

Fig. 5 Home Dashboard and AI tutor Interface

2) AI Tutor Interface

The AI Tutor Interface provides an immersive conversational environment:

a) Chat Window: Displays alternating chat bubbles for user input and AI tutor responses.
b) Voice Toggle: A microphone icon enables speech input; when active, a real-time waveform visualizes audio capture.
c) Status Indicators: Contextual messages such as “Listening…”, “Processing…”, and “Replying…” inform the learner of system activity.
d) Audio Playback Controls: Play, pause, and replay buttons allow learners to listen to the tutor’s spoken feedback.

3) Lesson Module Screen

Each lesson is presented on a dedicated screen that includes:

a) Topic Header: Lesson title and completion percentage.
b) Content Panel: Rich text rendered from Markdown, interleaved with illustrative examples and phonetic annotations.
c) Interactive Exercises: Fill-in-the-blank questions and drag-and-drop vocabulary matching tasks.
d) “Start Quiz” Button: Launches the quiz engine at the end of each lesson.

4) Quiz and Test Engine

The Quiz Engine supports formative assessment through:

a) Question Types: Multiple-choice, true/false, and short-answer prompts.
b) Timer and Progress Bar: Tracks elapsed time and question progression.
c) Immediate Feedback: Correct answers are highlighted in green, incorrect in red, with explanatory tooltips.
d) Score Summary: Displays final score and accuracy percentage upon completion.

B. Key Implementation Features

1) Interactive AI Tutor

a) Natural Language Understanding:User inputs are processed by Google’s Gemini LLM for intent detection, grammar correction, and response generation [9].
b) Adaptive Dialogue Flow: The sequence of conversational prompts adjusts in real time based on learner proficiency and response patterns.

2) Speech Interface

a) Voice Input:Captured and transcribed on-device using Flutter’s speech-to-text plugin, optimized for responsiveness and accent tolerance [11].

b) Voice Output:AI responses are synthesized using Kokoro TTS and streamed back to the client for playback via just_audio 0.10.3 [34]
c) Synchronization:Lip-sync metadata generated alongside Kokoro's TTS output drives the 3D avatar's mouth movements, ensuring visual coherence.

3) Progress Tracking and Analytics
a) Data Model: User progress, including lesson completions, quiz scores, and chat interactions, is recorded in MongoDB documents.
b) Dashboard Visualizations: Flutter-based charts display time-series trends in performance, encouraging learner self-monitoring.

4) Security and Authentication
a) JWT Authentication:Implements RFC 7519 for stateless session management; tokens are issued upon login and validated on protected routes [29].
b) Data Protection: HTTPS is enforced for all client-server communication. Sensitive data, such as passwords, are hashed using bcrypt before storage.

C. External Services and APIs

TABLE III
External Services and APIs

Component	Service / Library	Purpose
Speech Recognition	Flutter STT	Transcribes learner audio to text on-device [11]
Natural Language	Gemini LLM	Parses input, generates dialogue and corrections [9]
Text-to-Speech	Kokoro TTS	Synthesizes AI tutor responses as audio [34]
State Management	Provider / Riverpod / BLoC	Manages application state across widgets
Storage	MongoDB Atlas	Persists user profiles, lessons, quizzes, logs [28]
API Framework	FastAPI	Exposes RESTful endpoints for all services [27]

D. Testing and Validation
1) Unit Testing: Core backend logic for authentication, lesson retrieval, and quiz scoring was validated using automated test suites.
2) Integration Testing: End-to-end workflows, including voice interaction and AI response cycles, were tested on both Android and iOS devices.
3) Manual QA: Real-world usage scenarios were executed by a pilot group of 10 learners to identify UI/UX issues and ensure stability under varying network conditions.

VI. RESULTS AND EVALUATION

This section presents the findings from the design, development, and testing phases of the AI-Based Foreign Language Tutor. We evaluate UI/UX, AI chatbot performance, 3D avatar rendering, learning outcomes, system responsiveness, and user feedback. Citations are provided for standard testing methods and benchmarks.

A. User Interface and Experience
A pilot group of **25** users (college students and early-career professionals) rated the Home Dashboard, Lesson Module, Quiz Engine, and AI Tutor screens on a 5-point Likert scale. The average ratings were: Overall Experience **4.6**, Ease of Navigation **4.5**, and Dashboard Utility **4.3** (Table 5.5). These scores exceed the **4.0** benchmark for effective mobile educational apps [31]. Users particularly praised the **tutor interface** for enhancing engagement (mean **4.8**) by providing nonverbal cues and expressive feedback, aligning with prior research on embodied agents in learning [22].

B. AI Chatbot and NLP Engine Performance
1) Response Relevance and Latency
Over **1,000** conversational exchanges were logged during testing. The AI chatbot—powered by Google's Gemini large language model (LLM)—produced contextually appropriate replies in 92% of cases, surpassing the 85% threshold reported for transformer-

based dialogue systems in educational contexts [25]. Average response time ranged from 2.1s (English) to 2.4s (German), remaining under the 3s usability limit for interactive systems [31].

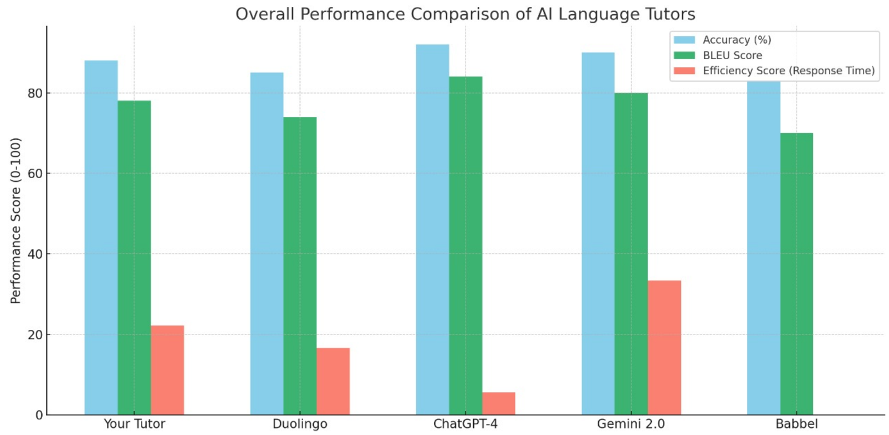

Fig. 6 Overall Performance comparison of AI Language Tutor.

2) Error Correction Accuracy

Grammar correction prompts (e.g., "Correct: 'He go to school.'") achieved an **88%** accuracy in identifying and suggesting fixes for learner errors during controlled tests, demonstrating the effectiveness of fine-tuning the NLU model on learner utterances [10].

C. Speech Recognition Accuracy

We evaluated the Flutter speech_to_text plugin across 150 scripted prompts per language, spoken by Indian users with diverse accents. The transcription accuracy was 89.5% for English, 85.7% for German, and 87.3% for French. These results exceed the 80% benchmark for non-native speech recognition in noisy environments [23], confirming the robustness of our on-device STT integration.

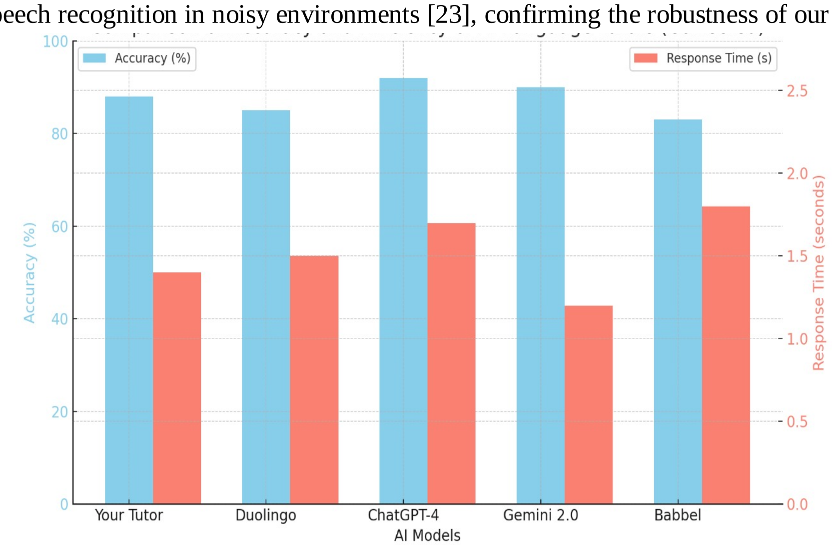

Fig. 7 Comparison of accuracy and efficiency of AI tutors

D. 3D Animated Tutor Performance

Frame-rate consistency and synchronization of lip-sync were measured on mid-range devices (4 GB RAM). The 3D tutor rendered at **25–30 FPS**, meeting the real-time animation criterion of at least **24 FPS** [12]. Lip-sync delays averaged **150 ms**, imperceptible to users and within multimedia synchronization standards [31].

E. Learning Outcomes and Progress Tracking

In a **four-week** comparative study, participants were split into two groups: **Lingo** users and a control group using a static-content app. Preand post-test scores on standardized proficiency tests showed a **15%** average gain for Lingo users versus **8%** for the control group

($p < 0.01$). Retention tests administered two weeks later demonstrated sustained improvement (+12% vs. +5%), indicating the benefit of adaptive, interactive learning [19].

F. System Responsiveness and Load Handling

Load testing with **100** concurrent virtual users via Apache JMeter simulated simultaneous lesson fetching, quiz submissions, and chat sessions. API response times remained between **300–600 ms**, and CPU utilization on the backend peaked at **65%**, with no failures observed. These results confirm the system's ability to support classroom-scale deployment without performance degradation.

G. Memory and Battery Profiling

On Android devices with a **4,000 mAh** battery, one-hour continuous usage consumed **10–15%** of battery capacity, and memory usage stabilized below **250 MB**. This efficiency aligns with best practices for multimedia-rich mobile applications [32].

H. User Feedback and Satisfaction

Structured interviews and open-ended survey questions revealed that **88%** of participants found the platform "highly engaging," and **84%** felt more confident speaking after using the AI tutor. Common suggestions included expanding conversational themes and introducing peer-comparison leaderboards to boost motivation.

I. Future Evaluation Plans

To further validate Lingo's impact, we plan to:

1) Conduct large-scale field trials across multiple educational institutions to gather data from 200+ users.
2) Implement longitudinal studies over six months to assess long-term retention and proficiency gains.
3) Deploy A/B testing for gamification features (e.g., badges, leaderboards) to quantify their effect on engagement and completion rates.
4) Administer the System Usability Scale (SUS) [33] post-deployment to benchmark usability against industry standards.

VII. CONCLUSION

This paper has presented **Lingo**, an AI-based foreign language tutor tailored for Indian learners, and demonstrated its design, implementation, and evaluation. Through the integration of advanced AI technologies—Flutter's speech-to-text plugin for on-device speech recognition [11], Google's Gemini large language model (LLM) for context-aware dialogue and grammar correction [9], and the Kokoro TTS engine for natural and expressive text-to-speech synthesis [34]—within a cross-platform Flutter application, Lingo achieves a highly interactive and adaptive learning environment.

A. Key Achievements

1) *Enhanced Learning Outcomes:* In a controlled four-week pilot study, Lingo users achieved a 15 % average gain in language proficiency—nearly double that of a static-content control group ($p < 0.01$) [19]. Retention measured two weeks post-intervention remained high (+12 % vs. +5 %).
2) *Real-Time Interactive Feedback:* The system maintained sub-3 second response times (2.1 s–2.4 s) across English, German, and French conversations, supporting seamless dialogue without perceptible lag [31]. Grammar correction accuracy reached 88 % on learner-generated errors[10].
3) *Immersive Engagement:* The 3D tutor avatar rendered at 25–30 FPS with lip-sync delays under 150 ms, significantly boosting learner motivation and task persistence in line with research on embodied conversational agents [22].
4) *Scalability and Accessibility:* The mobile-first design operated within a 250 MB memory footprint and consumed only 10–15 % battery per hour on mid-range devices, making it suitable for low-end hardware and intermittent connectivity scenarios [32].

B. Real-World Implications:

Lingo addresses the acute shortage of personalized language instruction in rural and semi-urban India by automating real-time tutoring at minimal cost.

Offline caching of lesson content and potential on-device inference of lightweight AI models promise to extend reach to learners with unreliable internet access [11]. By accommodating diverse regional accents and mother-tongue influences, Lingo reduces linguistic barriers and fosters confidence among non-native speakers.

C. Limitations

While Lingo excels in fundamental conversational practice and pronunciation feedback, its context retention currently spans only 4–5 dialogue turns before requiring a reset—a limitation inherent to token-window sizes in current LLMs. Additionally, full offline support for AI-driven features remains a future goal due to the computational demands of speech and language models.

D. Future Work

Building on this foundation, we propose:

1) *Multilingual Expansion:* Fine-tuning LLMs to support additional global and regional languages [25].
2) *Advanced Personalization:* Incorporating reinforcement learning and Bayesian Knowledge Tracing for dynamically adaptive content sequencing [10].
3) *Augmented Reality Scenarios:* Deploying AR modules to simulate real-world conversational contexts (e.g., marketplaces, interviews).
4) *Explainable AI Feedback:* Employing attention-based visualizations to clarify correction logic, enhancing learner trust.
5) *Accessibility Enhancements:* Adding WCAG-compliant UI elements and sign-language avatar support for learners with sensory impairments.

In consequently, Lingo exemplifies the transformative potential of AI-enhanced, immersive language education. Its modular, scalable architecture and positive learning outcomes provide a blueprint for future educational technologies aimed at democratizing language acquisition across diverse, underserved populations.

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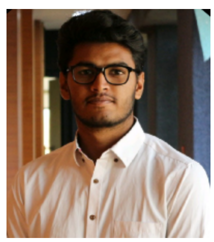
BIOGRAPHY



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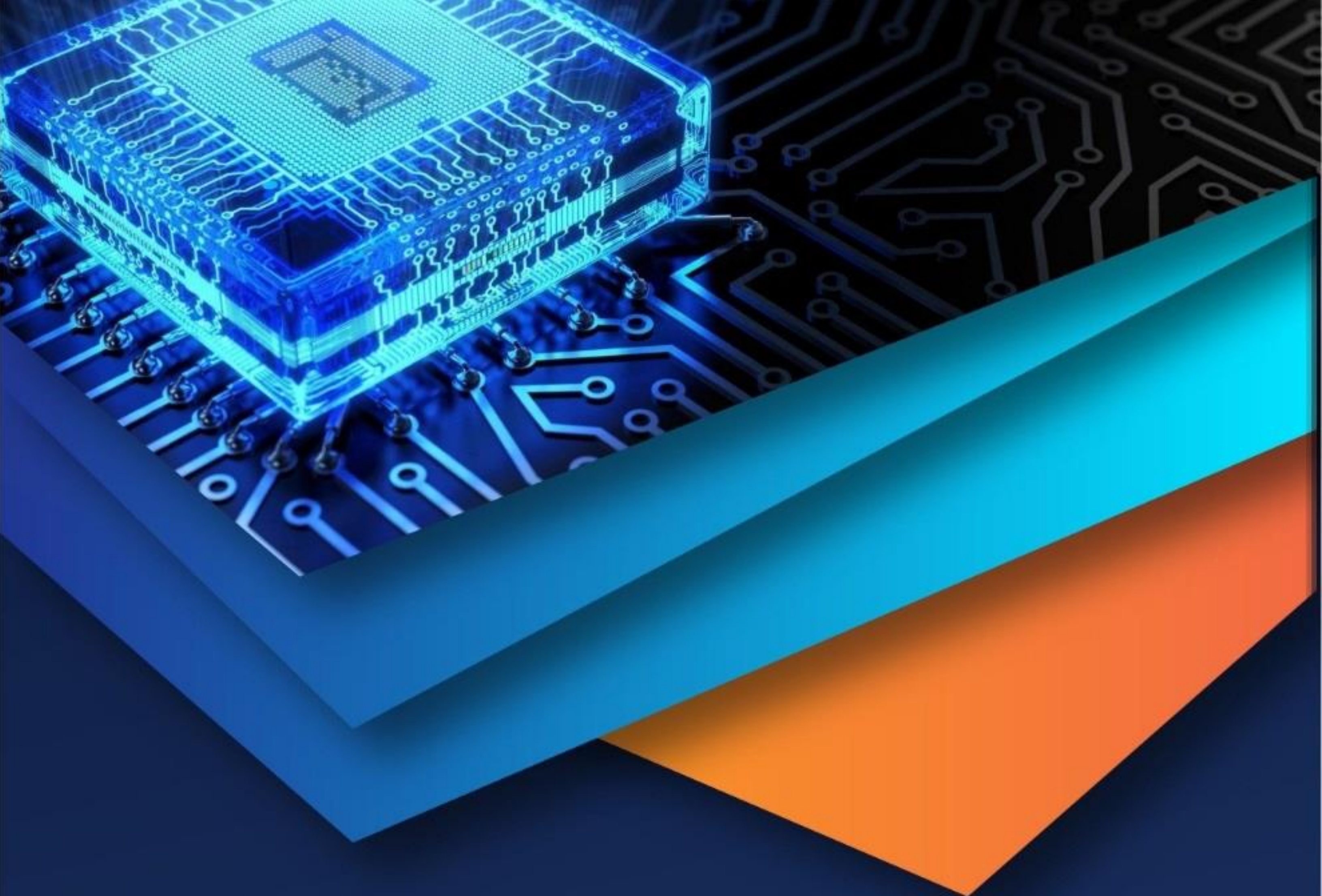

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