

AI-Powered Interactive Learning Assistant for Classrooms

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Abstract: In the era of personalized education, artificial intelligence can profoundly transform classroom learning experiences. EduBotics Assistant is an AI-powered interactive learning system designed to operate fully offline, making it ideally suited for schools and educational institutions with limited or no internet connectivity. The system integrates a Streamlit-based frontend with a Flask backend to deliver a seamless user experience across multiple input modalities text, voice, and images. Leveraging an optimized Gemma-2B large language model deployed via Intel’s OpenVINO toolkit, the assistant processes natural language queries in real time while ensuring low-latency, efficient CPU-based inference. For voice interactions, the system incorporates the Vosk speech recognition toolkit to transcribe spoken queries, and Tesseract OCR is employed to extract text from images. An interactive quiz module further enhances the learning process by dynamically generating multiple-choice questions based on user-defined topics, thereby supporting self-assessment and active learning. The fully offline design not only ensures data privacy and faster response times but also makes advanced educational tools accessible in remote or underserved regions.

Keywords: Offline AI Assistant, EduBotics, Gemma-2B, OpenVINO, Vosk, Tesseract OCR, Streamlit, Flask, Quiz Generation, Multimodal Learning, Educational Technology, Voice Recognition, Image-Based QA, Self-Assessment.

1 Introduction

The integration of artificial intelligence (AI) into education is reshaping how students engage with learning materials, access information, and enhance comprehension. Despite these advancements, many educational institutions, especially those in rural or underserved regions continue to face challenges due to poor or absent internet connectivity. To address this gap, we present EduBotics Assistant, a fully offline, AI-powered interactive

learning platform designed specifically to function without any reliance on cloud services or online APIs.

This system enables students to interact through multiple input modes text, voice, and images and receive accurate, context-aware responses using a locally deployed language model. The assistant is built using a Python-based architecture, with a Streamlit frontend providing a simple, responsive, and user-friendly interface, and a Flask backend handling modular API-based interactions across all functionalities.

The backend is powered by the Gemma-2B language model, optimized using Intel's OpenVINO toolkit to ensure efficient and fast inference on CPU-based systems. Voice input is processed using the Vosk speech recognition toolkit, enabling accurate offline transcription, while image-based queries are supported through Tesseract OCR, extracting readable content from uploaded visuals for interpretation. Additionally, a dynamic quiz generation module allows students to generate and take topic-specific multiple-choice quizzes, promoting interactive self-learning and knowledge assessment.

With all models and dependencies hosted locally, the EduBotics Assistant maintains complete offline functionality, ensuring data privacy, low latency, and system reliability. This makes it a scalable and accessible solution for educational environments with limited resources, bringing intelligent and multimodal learning support to classrooms without the need for internet connectivity.

2 Libraries Used

In the project for various tasks, following packages are used.

```
flask
flask_cors
transformers
optimum.intel
PIL (Pillow)
pytesseract
torch
wave
os
subprocess
json
numpy
vosk
requests
sounddevice
soundfile
tempfile
base64
streamlit
```

3 Methodology

To develop a fully offline, intelligent educational assistant tailored for classroom environments, we adopted a modular, multi-modal architecture. The system supports various input types text, voice, and images and delivers accurate educational responses using offline

natural language processing, speech recognition, and image analysis. The methodologies are designed for real-time performance on local hardware without relying on internet access.

Offline AI Inference with OpenVINO.

- **Model Deployment:** The Gemma-2B language model is optimized using Intel OpenVINO toolkit for efficient CPU-based inference.
- **Latency Optimization:** Model execution time is significantly reduced, allowing faster and more interactive learning experiences even without GPU or cloud support.

Natural Language Processing (NLP).

- **Prompt Engineering:** User questions are embedded within structured prompts to guide the model in generating focused, relevant answers.
- **Tokenization:** Hugging Face's AutoTokenizer is used to prepare text for the model.
- **Response Extraction:** Raw model output is filtered to extract only the relevant answer portion using string parsing.

Voice Input Processing.

- **Audio Capture:** The Streamlit frontend records voice input using the system microphone.
- **Conversion and Transcription:** The audio is converted to .wav using FFmpeg and transcribed using the offline Vosk model.
- **NLP Integration:** Transcribed text is then processed through the AI model for response generation.

Image-Based Question Processing.

- **OCR Extraction:** Tesseract OCR processes uploaded images to extract readable text.
- **AI Querying:** The extracted text is embedded in a prompt and passed to the AI model for interpretation and response.

Dynamic Quiz Generation.

- **MCQ Creation:** The user inputs a topic, and the AI model returns a JSON array containing five MCQs.
- **Frontend Parsing:** Streamlit dynamically displays the questions and captures user responses via radio buttons.
- **Evaluation:** On submission, user answers are validated against the correct ones, and the score is displayed immediately.

Flask-Based Backend API.

- **Modular Endpoints:** Four REST endpoints chat, voice, image, and quiz handle different input types.
- **Model Integration:** Each endpoint processes user input, formats it, and performs inference using the Gemma-2B model or Vosk for transcription.

Streamlit Frontend Interface.

- **Unified UI:** Built entirely in Python using Streamlit, offering a clean, intuitive browser-based interface.

- **Mode Selection:** Sidebar options let users switch between Chat, Image Q&A, Voice Q&A, and Quiz modes.
- **User Personalization:** A welcome screen captures the user's name and maintains conversational continuity.

Error Handling and Resilience.

- **Frontend Validation:** Prevents invalid inputs and provides user-friendly alerts.
- **Robust Backend Parsing:** Handles malformed JSON during quiz generation and logs raw outputs for debugging.
- **File Cleanup:** Temporary audio files are deleted after use to conserve system resources.

4 Implementation

The implementation of this offline AI-powered educational assistant is divided into three integrated modules: the Streamlit-based frontend interface, the Flask backend server, and the offline AI model inference pipeline. The complete architecture is optimized to work entirely offline on local machines without GPU or internet access.

Frontend Interface. The user-facing application is built entirely using Streamlit, allowing dynamic user interaction in a browser environment while running purely on Python. Upon startup, a welcome screen prompts the user to input their name and transitions to the main interface, which supports four core modes:

- **Text Q&A:** Allows users to type questions and receive AI-generated responses.
- **Voice Q&A:** Enables voice interaction by capturing microphone input (WebM), recording 5-second clips, and forwarding them for transcription.
- **Image Q&A:** Lets users upload an image (e.g., textbook snippet), which is then processed via OCR and sent to the AI for answers.
- **Quiz Generator:** Accepts a topic as input, generates 5 MCQs using the model, and dynamically displays them with interactive answer selection and scoring.

Each mode is accessed via a sidebar and switches seamlessly using Streamlit's session state management. All UI components including image uploads, radio buttons, and dynamic results are rendered using Python.

Backend Server: The backend is developed using `Flask` with CORS enabled for secure cross-origin communication with the frontend. The backend exposes multiple endpoints that process user queries based on modality:

- `chat`: Accepts a text prompt, tokenizes it, and returns a response from the AI model.
- `voice`: Accepts voice recordings, converts them to WAV using FFmpeg, transcribes using the Vosk STT engine, and sends text to the model.
- `image`: Uses PIL and Tesseract OCR to extract text from uploaded images and queries the model.
- `quiz`: Accepts a user-defined topic and returns five structured MCQs as a JSON array using prompt-based generation.

Each request is tokenized via Hugging Face's `AutoTokenizer` and processed using an OpenVINO-optimized Gemma-2B model running locally on CPU.

Offline AI Model Inference. The AI inference stack is entirely offline and includes:

- **Gemma-2B (OpenVINO):** Deployed for generating answers to user queries and MCQ generation. Optimized for CPU execution.
- **Vosk:** Used for offline voice-to-text transcription, integrated with FFmpeg to preprocess audio.
- **Tesseract OCR:** Extracts text from uploaded images and supports image-based Q&A functionality.

All models are pre-downloaded and loaded at runtime. No internet or external APIs are required.

Error Handling and Robustness: The application includes built-in error validation across both frontend and backend. The frontend prevents empty input submissions and alerts users when recordings are missing. On the backend, try-except blocks capture errors such as malformed audio, failed model outputs, and JSON decoding failures (e.g., during quiz generation). Temporary files like audio clips are automatically removed after use.

Offline-Centric Design: The entire system is designed for disconnected environments. All models and libraries run offline, and the system is optimized for low-resource devices using CPU-based inference. This makes it suitable for classrooms, rural labs, or edge devices where cloud access is unavailable.

5 Results & Discussion

The EduBotics Assistant was successfully developed and evaluated as a fully offline, AI-powered educational support system. Built using a Streamlit frontend and a Flask backend, the system integrates four key functionalities **Text Q&A**, **Voice Q&A**, **Image Q&A**, and **Quiz Generation** all powered by the **Gemma-2B language model optimized with OpenVINO**. Additional modules include **Vosk** (for offline speech-to-text), **Tesseract OCR** (for image processing), and **FFmpeg** (for audio conversion).

The performance summary of all major modules in the EduBotics Assistant is shown in Table 1, highlighting average response times, models or tools used, accuracy levels, and user experience. This helps in evaluating the system’s overall efficiency and responsiveness across different input modes.

Table 1: Performance Summary of EduBotics Assistant Modules

No.	Module	Avg. Time	Model/Tool Used	Accuracy Level	User Experience
1	Text Q&A	6–12 sec	Gemma-2B (OpenVINO)	High (Contextual)	Informative and accurate
2	Voice Q&A	8–15 sec	Vosk + Gemma-2B	High (for clear speech)	Hands-free interaction
3	Image Q&A	7–12 sec	Tesseract + Gemma-2B	Moderate to High	Good with printed text
4	Quiz Generator	10–18 sec	Gemma-2B (OpenVINO)	High Relevance	Real-time evaluation

An overview of the backend technologies integrated into the system can be found in Table 2. It lists the frameworks and tools used for each feature, demonstrating how different components such as Flask, OpenVINO, Vosk, and Tesseract are orchestrated to enable offline functionality.

Table 2: Backend Technologies Used in EduBotics Assistant

No.	Feature	Frameworks / Tools Used
1	Text Input	Flask + Gemma-2B (OpenVINO)
2	Voice Input	Flask + Vosk + FFmpeg
3	Image Q&A	Flask + Tesseract + Gemma-2B
4	Quiz Generation	Flask + Prompt Engineering + Gemma-2B

The system's features are further assessed in terms of usability and offline support in Table 3. This evaluation matrix outlines the input types accepted by each module, the level of offline support, and the relative ease of use, validating the assistant's practicality in classroom settings.

Table 3: Feature Evaluation Matrix

No.	Feature	Input Type	Offline Support	Ease of Use
1	Text Q&A	Text (Keyboard)	Fully Offline	High
2	Voice Q&A	Audio (Mic)	Fully Offline	Medium-High
3	Image Q&A	Image Upload	Fully Offline	Medium
4	Quiz Generator	Text (Topic)	Fully Offline	High

Text Q&A: Delivered highly contextual answers in 6–12 seconds using Gemma-2B. Ideal for fact-based academic queries.

Voice Q&A: Combined Vosk STT (3–6 sec) with AI inference (5–9 sec), giving a hands-free, responsive interaction.

Image Q&A: Tesseract OCR extracted printed text accurately. Output quality was moderately affected for handwritten or low-quality images.

Quiz Generation: Automatically generated 5 MCQs from a topic prompt with accurate scoring and UI integration. Response time: 10–18 seconds.

The results validate that the EduBotics Assistant meets the goal of providing intelligent and responsive educational support completely offline.

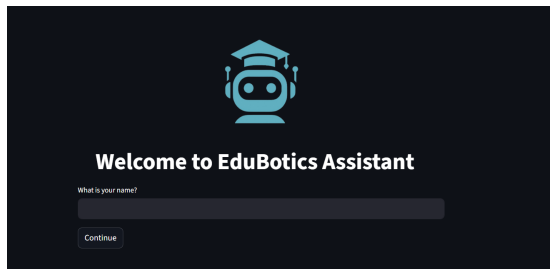
6 Conclusions

The development of the AI-powered Interactive Learning Assistant demonstrates the potential of combining advanced language models, voice recognition, and image processing

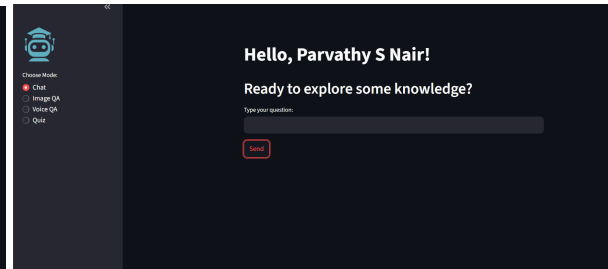
to create a comprehensive educational tool that works entirely offline. By leveraging technologies such as the OpenVINO-optimized Gemma-2B model, Vosk for speech recognition, and Tesseract OCR, the system provides a seamless and interactive learning experience across multiple input formats text, voice, and images.

One of the key strengths of this project lies in its ability to function without internet connectivity, making it highly accessible for schools and institutions in remote or under-resourced areas. The system not only answers academic questions effectively but also promotes active learning through a dynamic quiz generation module.

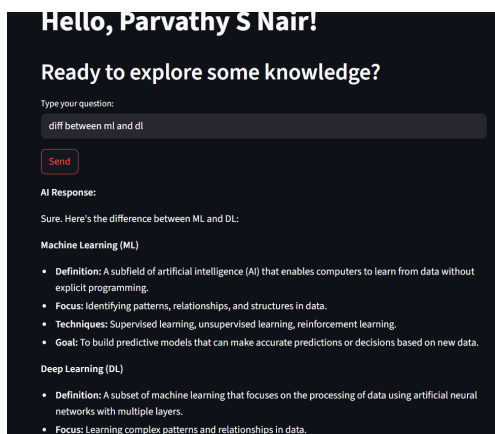
Its user-friendly interface ensures that both students and educators can engage with the assistant intuitively. Overall, this project successfully achieves its goal of creating an intelligent, offline educational assistant for classrooms. It opens the door for further enhancements, such as multilingual support, performance analytics, or content customization, which can further expand its utility and impact in the field of education.



Welcome screen prompting for user name



Main interface showing all features



Text Q&A: Chat input and response

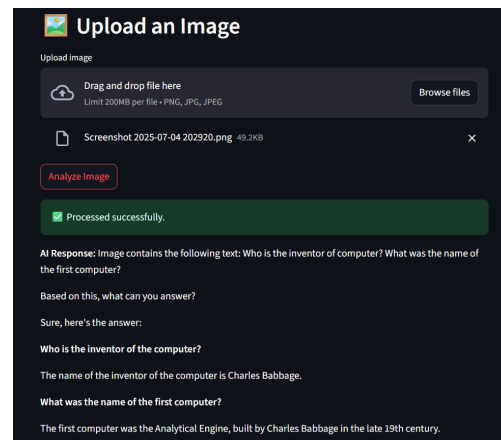
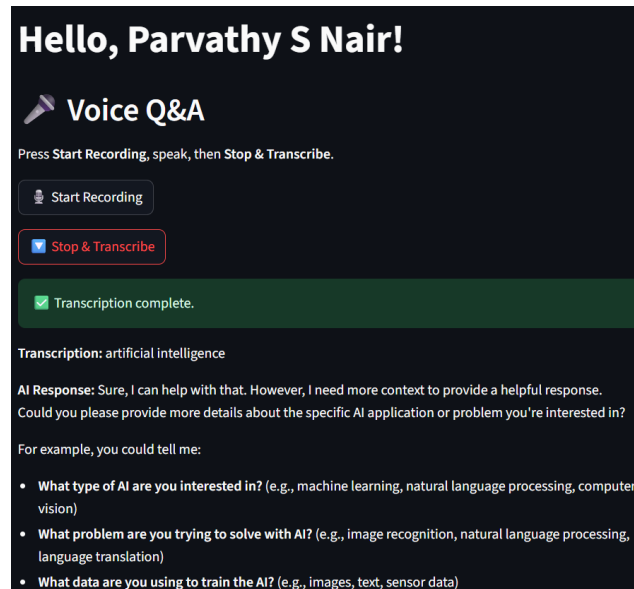
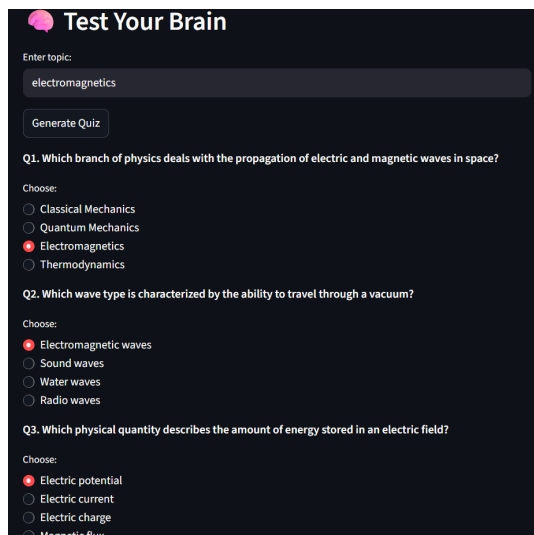


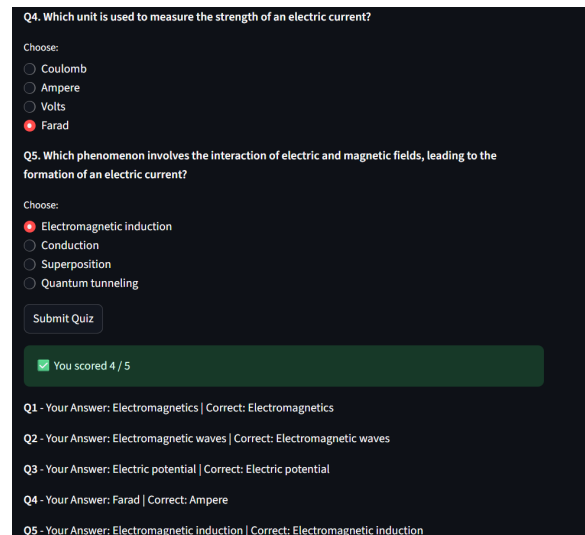
Image Q&A: Upload and analysis



Voice Q&A: Transcription and response



(a) Quiz-based Interaction



(b) Quiz generation and evaluation

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Individual Contributions

Elizabeth Benny

- Contributed to the development of the text-based chatbot feature, allowing users to input questions and receive AI responses.
- Assisted in setting up the input flow and ensuring a smooth conversational interface.
- Helped in formatting and refining the user interface for consistency.
- Actively participated in the preparation of the project report, especially in documenting the chatbot functionality and layout.

Navya R

- Worked on integrating the image-based question answering module, enabling the assistant to process uploaded images using OCR.
- Helped with the interface layout and flow of the image QA section.
- Supported the refinement of user experience in that module.
- Contributed to writing parts of the final report related to image processing and interface design.

Parvathy S Nair

- Led the complete design and development of the AI-powered web platform, ensuring all modules were integrated into a unified and fully offline-capable system.
- Built and implemented the voice-based interaction system using Vosk for offline speech recognition and AI-based response generation.
- Developed the topic-wise quiz generator with automatic evaluation and scoring features.
- Managed the backend integration, model handling, audio processing, and seamless coordination between all features.
- Played a major role in testing, optimization, and final validation of the platform, while also assisting in structuring and reviewing the overall project report.

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A Main code sections for the solution

A.1 Welcome User Input (Frontend - Streamlit)

Show welcome screen and collect user name.

```
if not st.session_state.entered:
    st.session_state.name = st.text_input(" What is your name?")
if st.button("Continue") and st.session_state.name.strip():
    st.session_state.entered = True
    st.rerun()
```

A.2 Text-based Chatbot (Frontend + Backend)

A.2.1 Frontend

```
question = st.text_input("Type your question:")
if st.button("Send") and question.strip():
    res = requests.post(f"{BACKEND_URL}/chat", json={"question": question})
```

A.2.2 Backend Endpoint

```
@app.route("/chat", methods=["POST"])
def chat():
    data = request.get_json()
    question = data.get("question", "").strip().lower()
    if question in ["hi", "hello", "hey"]:
        return jsonify({"answer": "Hello! How can I assist you today?"})

    prompt = f"User: {question}\nAssistant:"
    inputs = tokenizer(prompt, return_tensors="pt", truncation=True, max_length=1024)

    with torch.no_grad():
        output = model.generate(**inputs, max_new_tokens=150, do_sample=False,
                                pad_token_id=tokenizer.eos_token_id)
    reply = tokenizer.decode(output[0], skip_special_tokens=True).split("Assistant:")[1].strip()

    return jsonify({"answer": reply})
```

A.3 Image-based Question Answering (OCR + QA)

A.3.1 Frontend

```
uploaded = st.file_uploader("Upload image", type=["png", "jpg", "jpeg"])
res = requests.post(f"{BACKEND_URL}/image", files={"image": uploaded})
```

A.3.2 Backend Endpoint

```
@app.route("/image", methods=["POST"])
def image_qa():
    image = request.files["image"]
    img = Image.open(image.stream).convert("L")
    extracted_text = pytesseract.image_to_string(img)
    prompt = f"Image contains the following text:\n{extracted_text.strip()}"
    inputs = tokenizer(prompt, return_tensors="pt", truncation=True, max_length=1024)

    with torch.no_grad():
        output = model.generate(**inputs, max_new_tokens=150, do_sample=False,
                                pad_token_id=tokenizer.eos_token_id)
    reply = tokenizer.decode(output[0], skip_special_tokens=True).split("Assistant:")[1].strip()

    return jsonify({"answer": reply})
```

A.4 Voice-based Question Answering (Voice to Text + QA)

A.4.1 Frontend

```
audio_data = sd.rec(...)
sf.write(tmp.name, audio_data, ...)
res = requests.post(f"{BACKEND_URL}/voice", files={"audio": f})
```

A.4.2 Backend Endpoint

```
@app.route("/voice", methods=["POST"])
def voice():
    audio = request.files['audio']
    wav_path = "input.wav"
    audio.save(wav_path)
    subprocess.run(["ffmpeg", "-y", "-i", wav_path, "-ar", "16000", "-ac", "1", "
                    converted.wav"])

    wf = wave.open("converted.wav", "rb")
    recognizer = KaldiRecognizer(vosk_model, wf.getframerate())
    result_text = ""
    while True:
        data = wf.readframes(4000)
        if len(data) == 0:
            break
        if recognizer.AcceptWaveform(data):
            result_text += json.loads(recognizer.Result()).get("text", "") + " "
    result_text += json.loads(recognizer.FinalResult()).get("text", "")
    transcription = result_text.strip()
    prompt = f"User: {transcription}\nAssistant:"
    inputs = tokenizer(prompt, return_tensors="pt", truncation=True, max_length=
                        1024)

    with torch.no_grad():
        output = model.generate(*inputs, max_new_tokens=150, do_sample=False,
                                pad_token_id=tokenizer.eos_token_id)
    reply = tokenizer.decode(output[0], skip_special_tokens=True).split("Assistant:")[1].strip()

    return jsonify({"answer": reply, "transcription": transcription})
```

A.5 Quiz Generator (Topic-Based MCQs)

A.5.1 Frontend

```
res = requests.post(f"{BACKEND_URL}/quiz", json={"topic": topic})
```

A.5.2 Backend Endpoint

```
@app.route("/quiz", methods=["POST"])
def quiz():
    data = request.get_json()
    topic = data.get("topic", "").strip()
    prompt = f"""
    Generate exactly 5 multiple-choice questions on the topic "{topic}"""
```

```

Each must be a JSON object with "question", "options", and "answer".
Return only a JSON array of 5 such objects.
"""
    inputs = tokenizer(prompt, return_tensors="pt", truncation=True, max_length=
                        512)
    with torch.no_grad():
        output = model.generate(**inputs, max_new_tokens=700, pad_token_id=
                                tokenizer.eos_token_id)
    decoded = tokenizer.decode(output[0], skip_special_tokens=True)
    json_data = decoded[decoded.find("["):decoded.rfind("]") + 1].replace("â€¦", ' ')
    questions = json.loads(json_data)
    return jsonify({"questions": questions})

```

B Model Initialization (Backend)

B.1 Gemma-2B Model via OpenVINO

```

model_dir = "openvino_model"
tokenizer = AutoTokenizer.from_pretrained(model_dir)
model = OVModelForCausalLM.from_pretrained(model_dir)

```

B.2 Vosk Voice Model

```

vosk_model_path = "vosk-model-en-us-0.22"
vosk_model = VoskModel(vosk_model_path)

```

B.3 Server App Launch

B.3.1 Backend Flask Runner

```

if __name__ == "__main__":
    app.run(port=5000)

```

B.3.2 Frontend Streamlit Config

```

st.set_page_config(page_title="EduBotics Assistant", layout="centered")

```