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1 September 2023

**Abstract**

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Acknowledgements

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# Introduction <This is Heading 1>

Introduce the project.

## Aims and Objectives

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## Report Structure

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# Analysis and Requirements

## Background and Literature Review

Since its inaugural release on November 30, 2022, ChatGPT amassed over a million subscribers within its first week. This generative AI tool dazzled many with its sophisticated ability to undertake intricate tasks, especially in the realm of EFL (English as a Foreign Language) education. Such extraordinary abilities have evoked a spectrum of reactions from educators, as it transforms and redefines traditional pedagogical practices (Klyshbekova, 2023). Benefits attributed to ChatGPT in EFL encompass personalized and interactive learning, the generation of adaptive learning materials, provision of continuous and immediate feedback, fostering cultural understanding, and its 24/7 availability (Kohnke, Moorhouse and Zou, 2023). For instance, ChatGPT has demonstrated proficiency in generating dialogues tailored for students similar to the Common European Framework of Reference for Languages (CEFR) levels A and B1 (Young and Shishido, 2023). Adaptations of ChatGPT have effectively performed the role of an EFL teacher, assisting students with their writing tasks in regions like South Korea and Indonesia (Fitria, 2023; Han *et al.*, 2023). Moreover, EFL instructors in Vietnam acknowledged ChatGPT's potential in generating teaching materials and structuring EFL courses (Nguyen, 2023). It has been established that ChatGPT is adept at detecting grammatical errors, assisting Japanese EFL students in grammar acquisition (Schmidt-Fajlik, 2023). Remarkably, ChatGPT has been successfully deployed as a reading comprehension exercise generation system, offering qualified and individualized reading materials for middle-school English students in China (Xiao *et al.*, 2023). Consequently, such advantages have amplified the motivation among EFL learners to hone their reading and writing skills (Ali *et al.*, 2023). Yet, the technology is not devoid of limitations.

While ChatGPT's foundation is predominantly text-based, its inability to address speaking and listening skills emerges as a palpable drawback. Although EFL students generally exhibit a positive motivation towards reading and writing exercises facilitated by ChatGPT, their sentiments regarding its efficacy in nurturing listening and speaking proficiencies remain ambivalent(Ali *et al.*, 2023). It is recommended to conceive a comprehensive foreign language learning tool, which includes Augmented Reality, Voicebots, and ChatGPT technologies, thereby delivering a unique experience for EFL learners (Topsakal and Topsakal, 2022). Consequently, the assimilation of voice input and output mechanisms becomes imperative to fully harness the capabilities of ChatGPT in language learning.

Yet, other concerns still persist. Despite ChatGPT's aptitude in transforming auxiliary learning materials into interactive study resources, the quality and accuracy of such narratives remain under scrutiny (Diwan *et al.*, 2023). ChatGPT, on occasions, might produce misinformation or biased perspectives. Predominantly, the data it relies upon is procured from English sources and subsequently translated into various languages, such as Chinese or Japanese (Diwan *et al.*, 2023). Users also face the challenge of designing prompts to guide ChatGPT towards desired outputs—a process often daunting for non-technical individuals(Woo, Guo, and Hengky Susanto, 2023). Possible remedies involve furnishing structured learning materials to complement ChatGPT's capabilities or deploying a combination of hidden prompts to guide ChatGPT and open prompts for user initiation, ensuring a more refined feedback loop.

Furthermore, ChatGPT does not encompass features to record learners' progression or prompt them for periodic reviews. The technique of spaced repetition review, however, stands as a pivotal, economical, and effective learning strategy with immense potential to augment educational results (Kang, 2016). This method, aimed at reinforcing long-term retention, relies on strategically timed reviews premised on the forgetting curve—a principle that underpins numerous study systems (Yang, Oh and Youm, 2016). Empirical evidence reveals that EFL students who engaged in spaced repetition exercises for merely three minutes daily witnessed a threefold surge in long-term vocabulary retention (Chukharev-Hudilainen and Klepikova, 2016). Hence, the integration of a monitoring mechanism and a spaced repetition review system in educational software becomes indispensable.

In summary, while ChatGPT holds numerous advantages for EFL learners, its optimal utilization necessitates a combination of supplementary learning materials, efficient prompt management, voice integration, a robust learning tracking mechanism and spaced repetition strategy.

## Requirements Gathering

Basing on the previous literature review, this part will investigate and compare functionality of the existing applications related to EFL education. Furthermore, to obtain a deeper understanding of user perspectives regarding EFL software and the incorporation of ChatGPT, interviews were conducted with four EFL learners.

### Analysis of Existing Applications

According to the result of literature review, five salient features intrinsic to EFL software were identified: integration of AI technology, learning material, voice integration, learning tracking mechanism and spaced repetition review system. While these form the primary attributes, other desirable features will also be examined in this analysis. For a comprehensive understanding, three popular EFL websites have been chosen for a thorough evaluation of the merits and potential shortcomings of these applications.

**Duolingo** is one of the most popular language learning applications. As presented in its introduction, it embraces the prowess of AI with established language pedagogies to curate tailored learning courses(Duolingo, 2023). The platform promises a comprehensive curriculum that covers crucial language domains, such as reading, writing, listening, and speaking. Although it also incorporates its voice function in courses and practices, the review system doesn’t follow spaced repetition rules. The website also emphasizes the gamified nature of learning. Earning points, unlocking levels, and interacting with their mascot, Duo the Owl, are elements that underscore Duolingo's commitment to making language acquisition both engaging and habit-forming.

**Glossika** positions itself as an innovative platform because of adaptive learning algorithms and an extensive database of handpicked sentences (Glossika, 2023). With a strong emphasis on customization, the platform crafts content in alignment with users' competency levels and interests. By immersing learners in full-sentence contextual practice, Glossika ensures a combination of vocabulary, pronunciation, listening, reading and writing practices. Another intriguing aspect of Glossika's approach is its promised use of a spaced repetition algorithm, designed to obviate the often-daunting task of memorization. This ensures that learners receive timely prompts on phrases they're easily to forget, offering a seamless learning curve. Furthermore, authenticity is emphasized by the platform's incorporation of native speaker audio for every sentence. This allows learners to not just assimilate accurate pronunciation but also self-assess their progress by recording and comparing their accents over time.

**Langotalk**, an innovative startup, harnesses the potential of ChatGPT technology to redefine EFL education (Langotalk, 2023). One of its standout features is the diversity of chatbots it offers, each built with a distinct personality tailored to imitate varied settings and specialized topics. This range enables learners to immerse themselves in a conversational context. While it doesn't offer a structured curriculum, Langotalk allows users to create notes and log study items. The chatbots can offer real-time, individualized feedback, acting not just as conversational partners but also as tutors to guide on expression choices and grammatical structures. However, the incorporation of voice input and output can only base on the conversation content. In addition, a noticeable gap in Langotalk's offering is the absence of a robust learning tracking mechanism and a systematic review system, which might be essential for EFL learners looking to monitor their progress methodically.

Figure 1: Comparison among Existing Applications

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Duolingo** | **Glossika** | **Langotalk** |
| **AI Technology** | AI-powered course recommendation and assessment. | AI-powered voice recognition and review algorithm basing on learning behavior and spaced repetition | ChatGPT |
| **Learning Material** | Well-structured and interactive courses martials for different level. | The sentences recommended by AI basing on user’s ability and preferences. | Not provided. Users can interact with chatbots directly and produce study content. |
| **Voice Integration** | Voice input and output for materials and review exercises. | Voice input and out for vocabulary and sentences practices. | Voice input and output for conversation texts. |
| **Learning Tracking Mechanism** | Record the courses which have accomplished. | Well recorded study progress and review schedule. | Not provided. But users can make study notes. |
| **Spaced Repetition Review System** | Review system but does not mention using spaced repetition strategy. | Individualized review schedule using spaced repetition algorithm. | No review system. |
| **Other** | Gamification and virtual rewards for achievements. | Weekly study report. | Various chatbots with different personality. |

The comparative analysis of the three EFL education software, as presented in the table above, highlights distinct strengths and areas of improvement for each. Traditional application, Duolingo and Glossika, prioritize high-quality learning materials, underscored by their robust learning and review mechanisms. However, their structured approach may somewhat scarify the flexibility and tailored experiences many modern learners seek. In contrast, Langotalk, capitalizing on its innovative approach, outstands in delivering rich, personalized learning experiences tailored to individual EFL learners. Meanwhile, its conspicuous absence of a learning progress monitoring system, week quality assurance for learning materials, and a systematic review mechanism somewhat diminish its overall user experience. Noteworthy across the board, though, is the seamless integration of voice features, enhancing the user's learning experience in all the platforms.窗体顶端

### Interviews

To gain richer insights into the experiences of perspective learners using EFL education software and ChatGPT, four participants were recruited to join an structured interview, the details of which are provided in Appendix A. These participants, native speakers of either Mandarin or Cantonese, reside in the UK. Findings indicated that while all participants had utilized EFL software for English language learning, their familiarity with ChatGPT's interactive features didn't necessarily sway their preference. Despite recognizing the potential benefits of ChatGPT in facilitating English acquisition, traditional EFL education software remained their primary choice. Their preference was attributed to two notable factors: the lack of voice integration in ChatGPT and its absence of a systematic learning and review monitoring system. These reasons echo the sentiments expressed in our earlier discussions. The insights garnered from the interviews contribute to the establishment of application requirements, which will be elaborated upon in the subsequent section.

## Application Requirements

Through the above-mentioned research, a compilation of vital features has been identified. These features were prioritized using the MoSCoW methodology (refer to Appendix B) and substantiated with user stories (refer to Appendix C). This section delves into the key functional and non-functional requirements for the proposed application, *Langbuddy*.

### Functional Requirements

For an adaptive and holistic EFL learning experience, the application is designed around four main functional requirements:

**Structured Learning Material**

* **Diverse Course Offerings**: The platform should provide a spectrum of EFL courses, allowing users to select specific areas and levels they wish to bolster.
* **Seamless Integration**: Learning materials can be effortlessly integrated into the study plan system, auto-generating a structured study tasks with a pre-built schedule.

**Study Plan System**

* **Customization**: Users can craft and schedule their study tasks to fulfill their unique learning needs. This fosters autonomy, enabling learners to manage their educational journey flexibly.
* **Adaptability**: Users can inspect and modify their learning content and schedule as required.
* **Analytical Overview:** The platform offers statistical overview of a user's learning trajectory, enhancing their ability to strategize and plan ahead.

**Tailored AI Chatbot with Voice Interaction Ability**

* **Multi-interaction**: Users can communicate with the AI chatbot using both text and voice inputs. The chatbot, in turn, is equipped to respond vocally if required by users.
* **Versatile Chatbot Personalities**: Recognizing the diversified needs in EFL learning, distinct chatbot personalities should be curated for varied learning contexts and requirements.
* **Review Integration**: Conversational content can be flagged and seamlessly integrated into the review mechanism automatically, ensuring consistent learning progression.
* **Translation Capability**: For optimal comprehension, conversation content can be translated into the user's mother language when required.

**Review Mechanism with Spaced Repetition Strategy**

* **Automatically Integration**: The finished study task and noteworthy points from chatbot interactions can be seamlessly transitioned into the review system if required. Users can decide the review schedule and amend content in the integration process.
* **Customizability**: While the system offers preset spaced repetition schedules, users also have the autonomy to devise unique review timelines. Additionally, they can create and modify content and timelines as they progress.
* **Analytical Overview**: Users can see their review performance and progress through statistical insights. They can adjust their learning process basing on the information provided by the platform.

### Non-Functional Requirements

The project must also fulfill three non-functional requirements as part of its design and implementation.

**Usability**

The application user interface should be user-friendly and fast-loading. The design style should enable users to identify information easily and focus on learning tasks. Furthermore, the management of loading state, which refers to the waiting for response from chatbot and transformation between text and voice should be considered. Moreover, in instances of errors or unexpected user actions, clear and instructive hint messages should be presented, guiding users to rectify issues or understand the context better.

**Security and Privacy**

Before any personal information or voice data is accessed or processed, users should be informed and their consent is obtained, especially when data needs to be shared with third-party API providers to enable specific functionalities. The application should strictly maintain compliance with GDPR (General Data Protection Regulation) and ensure that personal and sensitive user information is safeguarded at the adequate level of security measures.

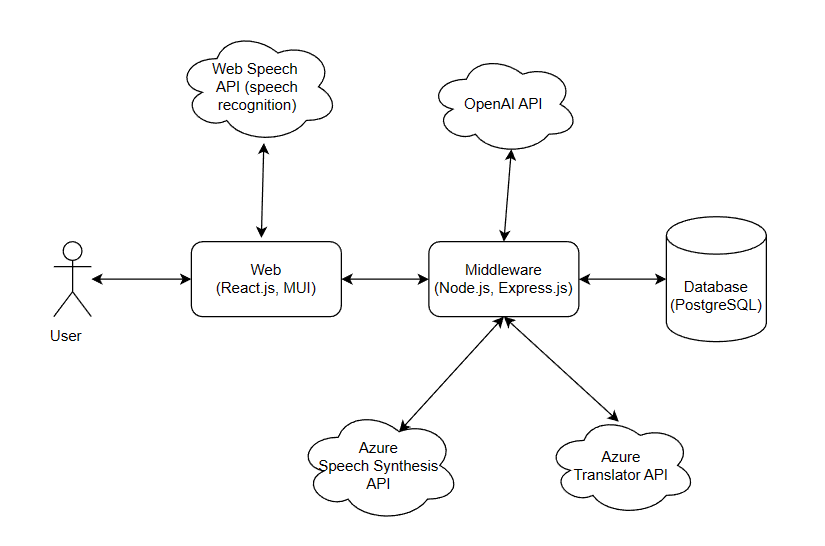
**Daily Interaction Limitation with Chatbot**

Given the reliance on third-party APIs, a reasonable restriction on user-chatbot interactions is enforced. This will prevent abusing these features and control the operational cost at an affordable level. Meanwhile, this limitation will also encourage the user to engage with Chatbot in a thoughtful and responsible manner.

# Design and Implementation

This part will illustrate the system architecture of this application. Then the user interface design and database design will be explained. Finally, the implementation of functionalities will be also elaborated.

## System Architecture



**Figure 2:** system architecture

This application system includes four parts: frontend, middleware, database and external API.

The frontend is developed using **React**, a widely-used JavaScript library known for building interactive user interfaces for single-page applications and maintained by Facebook (React, 2023). React's component-based approach ensures modularity, facilitating easier updates and maintenance. Moreover, it allows for the creation of dynamic and responsive web pages, enhancing the user experience, which is suitable for rendering the study items, review items and chat boxes repeatedly. Paired with React, the popular UI framework **MUI (Material-UI)** which implements Google’s material Design is chosen. MUI offers a set of React components tailored for faster and more efficient web development (MUI, 2023). It's designed for creating visually pleasing and intuitive user interfaces, making it especially suitable for an education-focused application that requires clear and accessible UI elements.

For the middleware, **Node.js** stands out as an ideal choice. This open-source, cross-platform JavaScript runtime environment is known for its efficiency in handling concurrent requests, essential for a responsive chatbot experience. Furthermore, its non-blocking I/O model ensures real-time updates, a crucial feature for any interactive and data-intensive platform. Node.js also has rich libraries which can be easily integrated with various function of the application. Complementing Node.js, **Express.js** is utilized. Express.js, being a minimal and adaptable Node.js web application framework, simplifies the process of crafting server-side applications, making the integration of features and APIs seamless and straightforward (Express, 2023).

For the application's data management needs, **PostgreSQL** is selected. Renowned as an advanced open-source relational database system, PostgreSQL offers key features such as extensibility, data integrity, and adherence to SQL standards. Within this application, the relationships between users, study tasks, review sessions, and chat history are intricate and tightly-knit. Such relationships are best modeled using a relational database paradigm. Relational databases, like PostgreSQL, excel in representing data entities and the connections between them in a structured manner. They are particularly adept at handling complex queries and ensuring data consistency. Given that application demands a clear representation of the relationship dynamics among its data elements, the feature ACID (Atomicity, Consistency, Isolation, Durability) of PostgreSQL is beneficial and essential for this software.

The application's capabilities are further magnified through a selection of external APIs:

* **OpenAI API**: Considering the chatbot's intelligence, OpenAI's API allows this software leverage the GPT’s advantage to generate human-like and qualified interactions. Given the nature of this application, it's vital that users get accurate and interactive EFL learning guidance and assistance from AI model, making this API an apt choice.
* **Web Speech API**: The Web Speech API encompasses a suite of tools and protocols offered by contemporary web browsers, enabling developers to integrate both speech recognition and speech synthesis (text-to-speech) capabilities seamlessly into web applications (Mozilla, 2023). Within the application, speech recognition feature is incorporated, primarily due to its ready accessibility and rapid response attributes. Facilitating interactions between users and chatbots through voice not only elevates the intuitiveness of the experience but also enhances user-friendliness, making the learning process more engaging.
* **Azure Speech Synthesis**: Aiding in the text-to-voice functionality, Azure Speech Synthesis offers voice outputs that closely mirror natural human speech. This enriches user interactions, making digital learning more immersive. Furthermore, the azure speech Synthesis API provides diverse accents and tones, which helps users learn different accents (Microsoft Azure, 2023a). The vivid output speech and various choices of accents outweighs the speech synthesis function provided by web speech API.
* **Azure Translator API**: The Azure Translator is employed for real-time, multi-language translations (Microsoft Azure, 2023b). This ensures that users, regardless of their linguistic background, can access content in their mother language when needed in the process of interacting with chatbots.

## User Interface

### Colour, Font and Style

The visual aesthetics of the application are predominantly shaped by the theme colour functions provided by MUI. The main colour is set to cyan, a hue known for its refreshing, calming, and modern characteristics (Canva, 2023). Cyan is associated with clarity and stimulates mental focus, which aligns with the educational intent of the platform. To complement this primary shade, light blue is selected as the secondary colour. This colour not only harmonizes well with cyan but also further emphasizes the cool, tranquil atmosphere conducive to focused learning. For certain interface elements, such as disabled buttons and components, the application employs a neutral grey. This default colour subtly signifies non-active or inaccessible features without detracting from the overall visual appeal.

As for the typography, the application utilizes the Roboto font. Given that our application's primary objective is to facilitate effective language learning, it's crucial to ensure readability and legibility in every textual element. Roboto achieves this by offering clear letterforms, making it easier for learners to engage with the content.

The style of application's user interface is rooted in simplicity and directness. By adopting a minimalist approach, any potential distractions are eliminated, ensuring that users can focus wholeheartedly on their studies. Every element, from the layout to the interactive components, is crafted to be intuitive and self-explanatory in order to reduce users’ cognitive overload.

### Components and Pages

This section highlights the crucial components and four primary pages of the application: the dashboard, study overview, review overview, and chatbuddy.

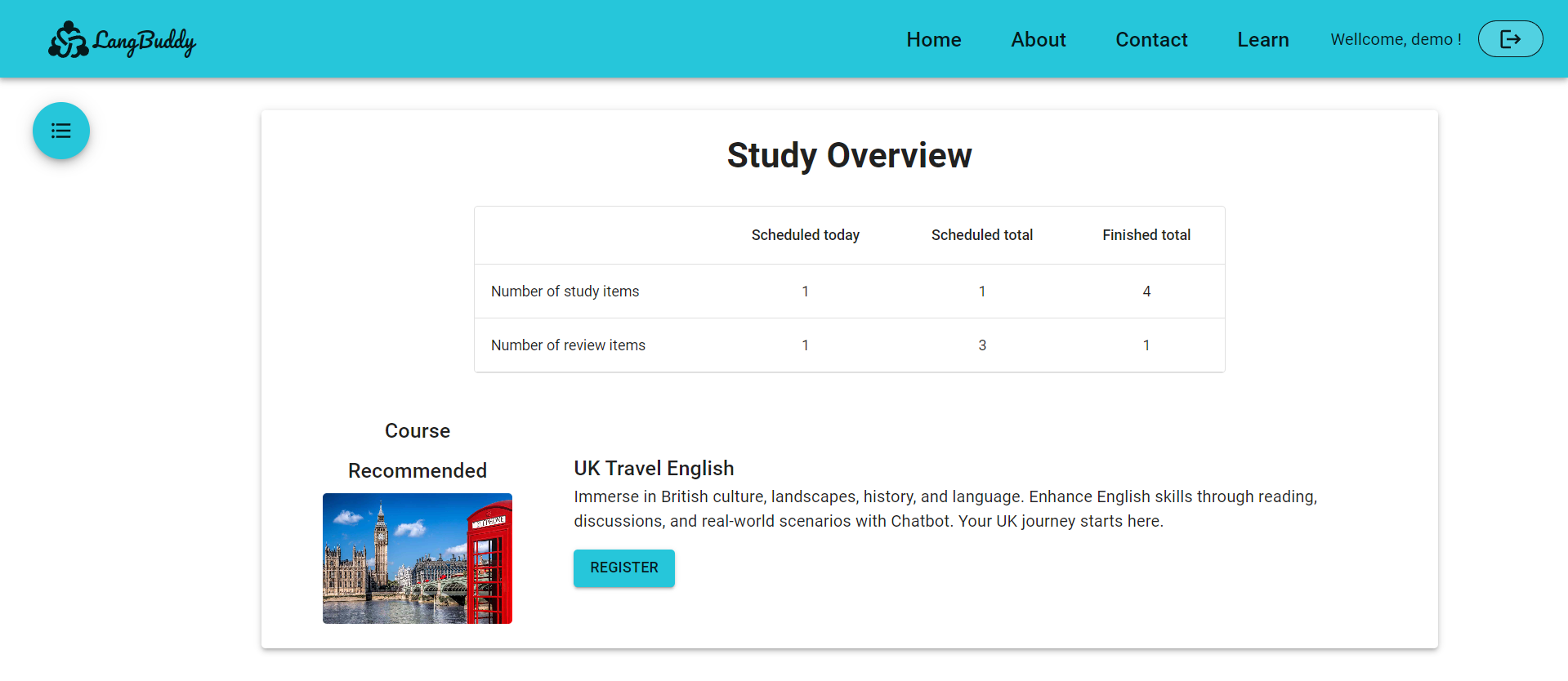


Figure 3: Dashboard Page

The dashboard showcases statistics for both study and review items, providing users with a clear insight into their learning progress. Additionally, a structured course is presented for demonstration purposes, enabling users to enrol and automatically generate default study items.

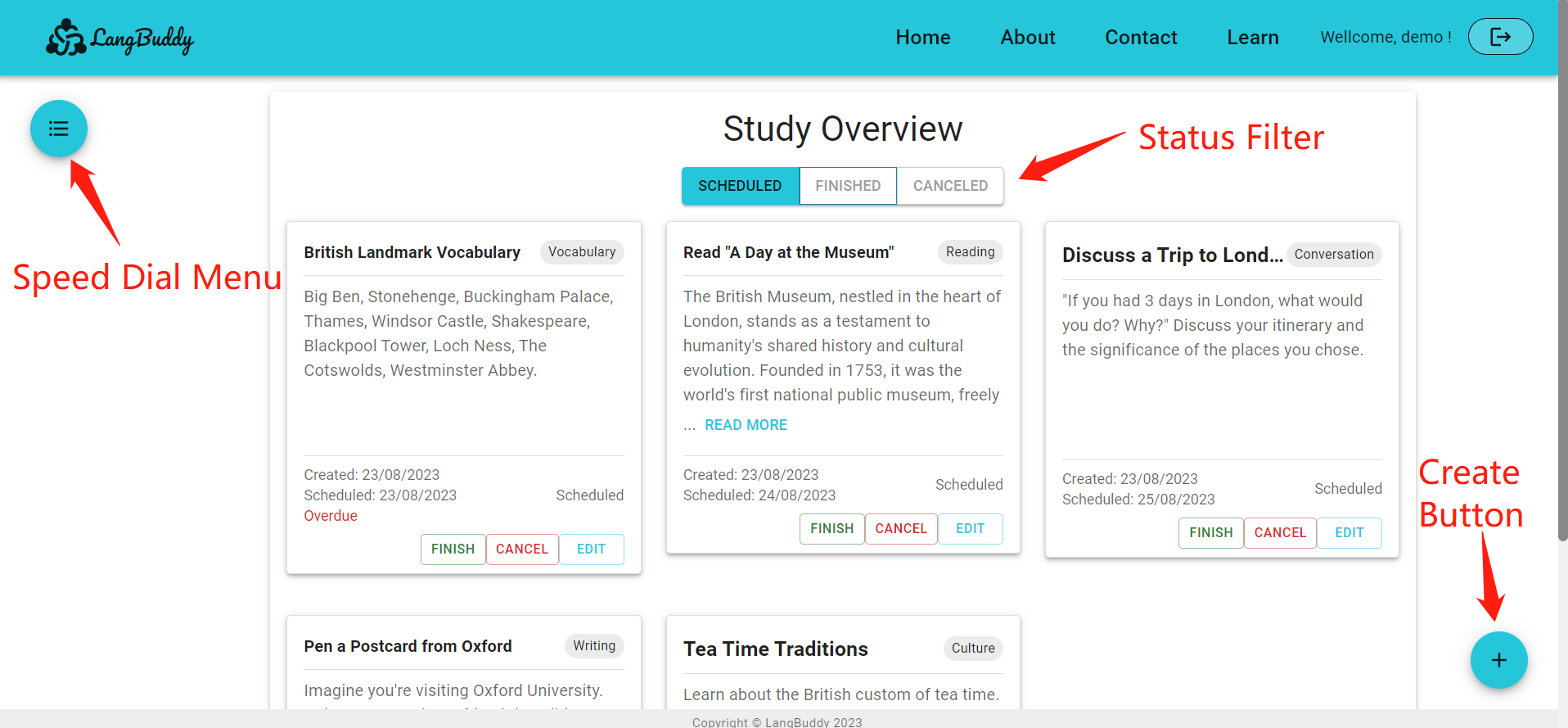


Figure 4: Study Overview Page

The study overview page displays study items through the study card component. These study cards can be organized based on their status: scheduled, finished, or cancelled. For scheduled items, cards are arranged in ascending order by scheduled date, while for finished and cancelled items, they are in descending order by completion date. This arrangement ensures that users can easily track and manage their study plans. Users can navigate to other pages using the speed dial menu and add new study items with the "create new study item" button.

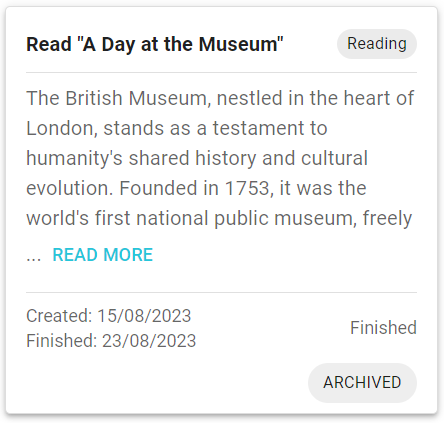
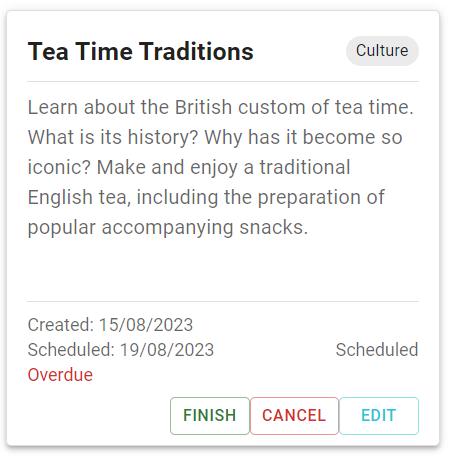


Figure 5: Study Card Component

Each study card offers essential details such as the title, category, content, creation date, and scheduled date. Depending on the status, additional features or buttons, including status changing and editing function, are available for user interaction. The study card will remind the user with red characters if it is overdue comparing to the scheduled date. For longer content, a "read more" option unfolds the content details in a modal view.

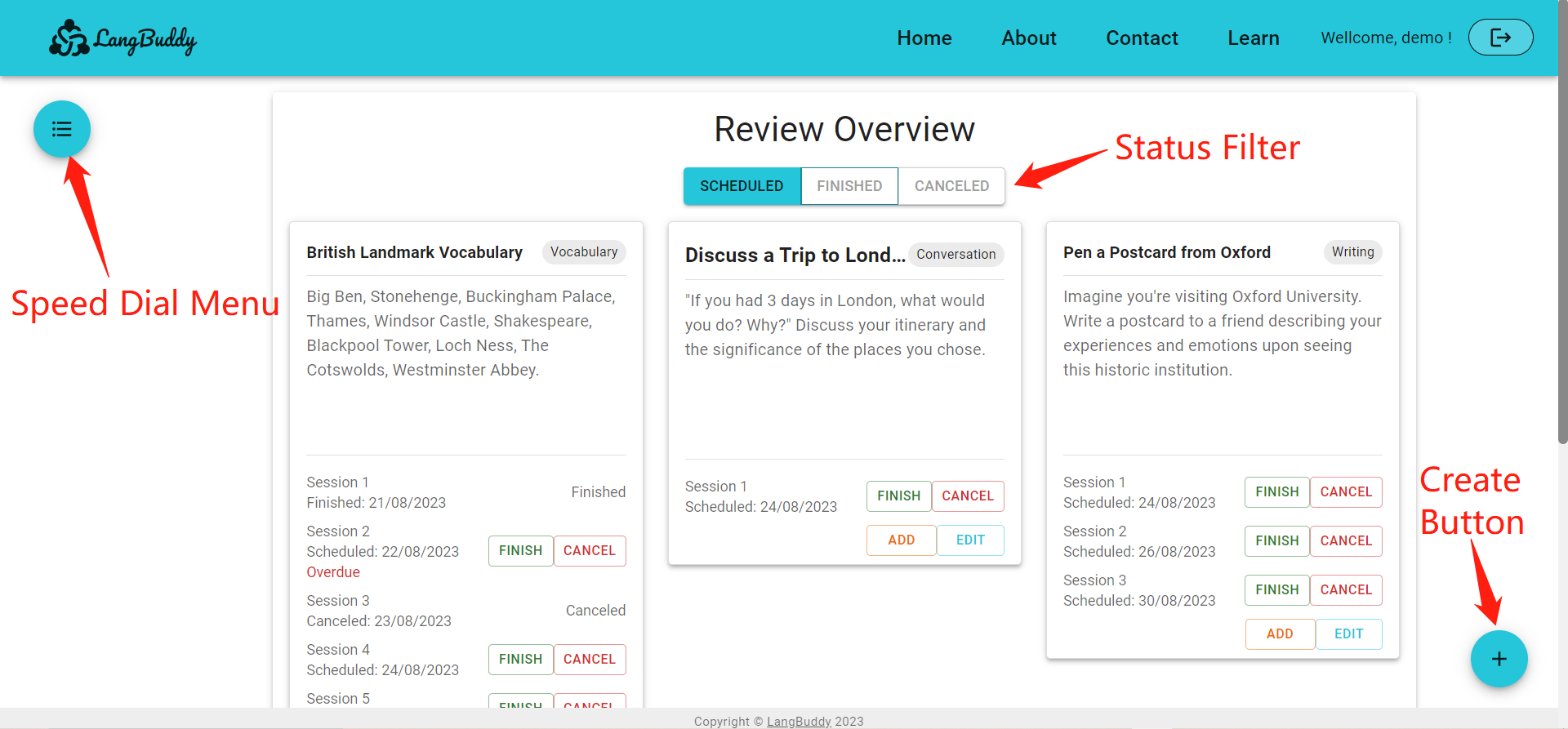


Figure 6: Review Overview Page

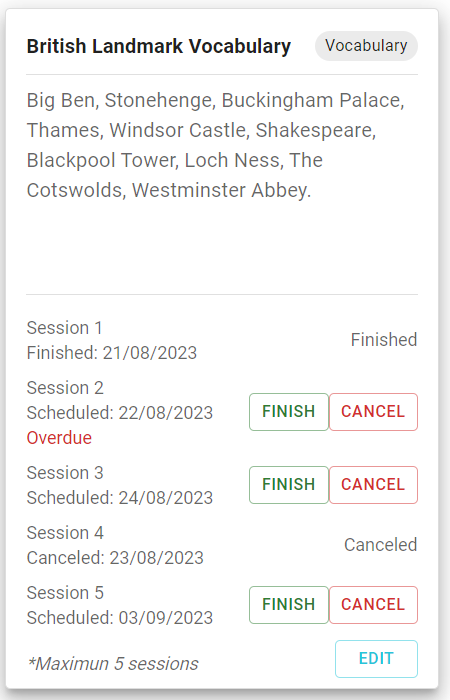
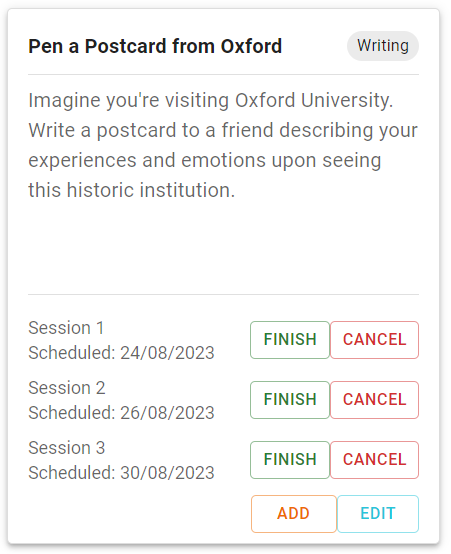


Figure 7: Review Card Component

The review overview page mirrors the organizational structure of the study overview page, listing all review cards based on their status. However, the layout for individual review cards differs from that of study cards. In addition to standard details (title, category, content and etc.), review cards showcase a set of session components that detail the scheduled date, completion date, status, and possible actions for each review session. Users have the flexibility to add or edit review item details and sessions, with a cap of five sessions for each review item. The overall status of a review item adjusts based on the completion or cancellation of all its sessions.

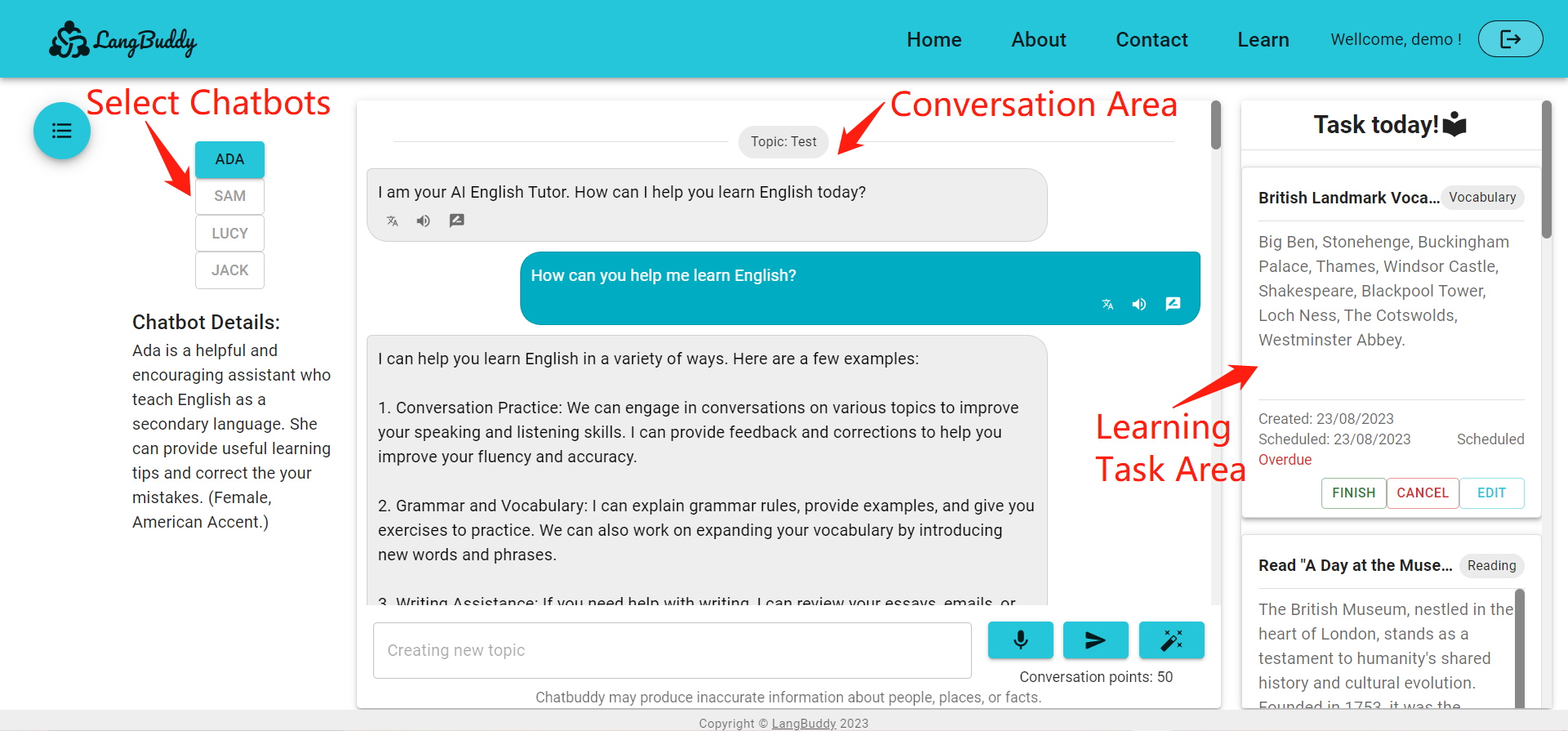
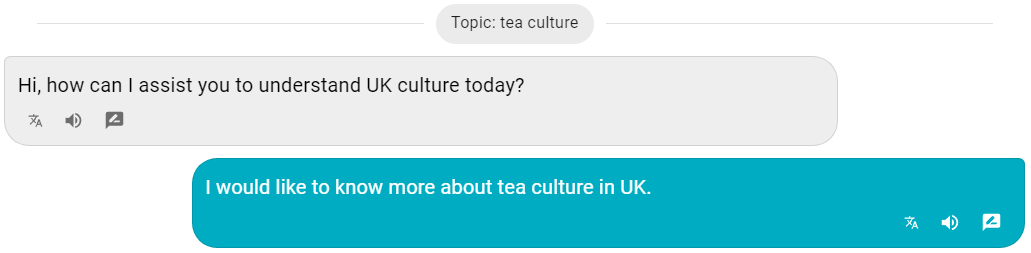


Figure 8: Chatbuddy Page

The chatbuddy page is structured into three main sections: chatbot selection, conversation area, and learning task area. In the chatbot selection section, users can choose a chatbot tailored to their specific learning objectives. The conversation area is where users interact with their chosen chatbot. Conversational history is displayed through a series of chatbox components. Users can type messages in a dedicated input area. This area also features three buttons: one for speech recognition, another for sending messages, and a third for initiating new topics. Beneath these buttons, conversation points are highlighted for user reference. Additionally, the learning task area showcases study tasks and review sessions scheduled for the current day, using the previously described study cards and review cards.



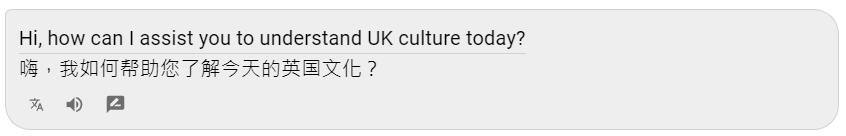
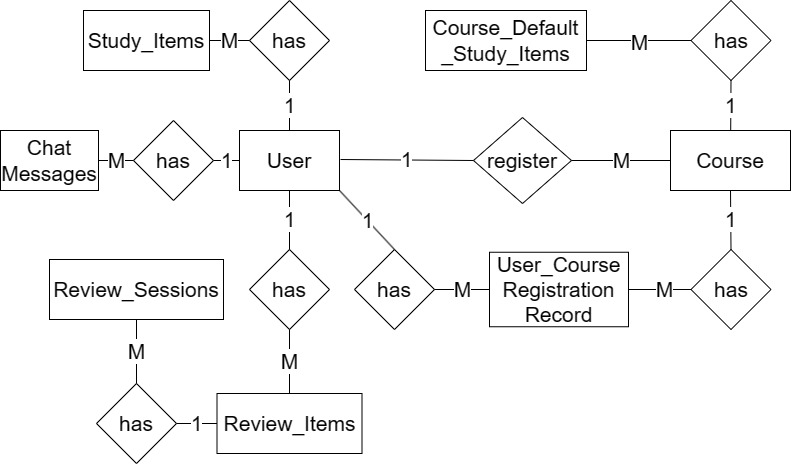


Figure 9: Chatbox Component

Diving deeper into the chatbox component, its appearance and features are determined by the 'role' prop. If its role is set as 'topic', it serves as a divider showcasing the topic's value. If the role is 'assistant', the chatbox appears on the left with a grey background. When the role is 'user', the chatbox is positioned on the right, boasting the theme's main color. Moreover, three functional buttons are present at the base of the chatbox for translation, text-to-speech, and review item creation. These functionalities are activated upon user interaction.

## Database Design



Above is an entity relationship diagram for the project. Identifying the entities and their relationships between each other is essential for good database design. Each entity also has associated attributes and constraints, these can be found in Appendix D.

## Function Implementation

### Structured Learning Courses

### Study Plan System

### Review System with Spaced Repetition Strategy

### Chatbot

### Security and Authentication

### User Experience and Errol Handling

# Testing and Evaluation

Show how you plan to organise your work, identifying intermediate deliverables and dates.

# Conclusion

[1] C. Baier and J.-P. Katoen. *Principles of Model Checking*. MIT Press, 2008.

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