AI CHILD BUDDY

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Bachelor of Software Engineering with Honours

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ABSTRACT

This project introduces Jang, a voice-activated AI companion designed to provide emotional support and educational interaction for children. Built using Python, Flask, and machine learning tools, Jang operates as a stand-alone Raspberry Pi-based system equipped with voice input/output, emotion recognition, and a simple animated face interface. The primary aim is to foster safe, offline child engagement through natural conversation, basic quizzes, and empathetic responses. Jang also integrates parental monitoring via event logging, allowing guardians to track interactions without direct access to conversations. This paper discusses the full development cycle, from requirement analysis and system design to implementation and testing. Functional and non-functional testing confirmed that Jang is effective in recognising user intent, responding appropriately, and maintaining usability standards. While limited by hardware constraints and local-only processing, Jang demonstrates the potential of affordable, voice-driven AI for child-centred use cases. Future work includes expanding Jang's emotional intelligence and refining the parental dashboard experience.

ABSTRAK

Projek ini memperkenalkan Jang, sebuah rakan AI yang diaktifkan melalui suara dan direka untuk memberi sokongan emosi serta interaksi pendidikan kepada kanak-kanak. Jang dibangunkan menggunakan Python, Flask, dan alat pembelajaran mesin, beroperasi secara kendiri melalui sistem berasaskan Raspberry Pi yang dilengkapi dengan input/output suara, pengecaman emosi, dan antara muka wajah animasi ringkas. Matlamat utama adalah untuk mewujudkan satu kaedah interaksi semula jadi yang selamat dan boleh diakses tanpa talian bagi kanak-kanak melalui perbualan, kuiz asas, dan respons empati. Selain itu, Jang menyepadukan pemantauan ibu bapa melalui log acara, membolehkan penjaga menjejaki interaksi tanpa perlu mengakses kandungan perbualan secara langsung. Kertas kerja ini membincangkan keseluruhan kitaran pembangunan, daripada analisis keperluan dan reka bentuk sistem hingga ke pelaksanaan dan ujian. Hasil ujian fungsi dan bukan fungsi menunjukkan bahawa Jang mampu mengenal pasti niat pengguna, memberi respons yang sesuai, dan mengekalkan piawaian kebolehgunaan. Walaupun terhad oleh keupayaan perkakasan dan pemprosesan setempat, Jang menunjukkan potensi AI berasaskan suara yang mampu dimiliki untuk kegunaan berfokuskan kanak-kanak.

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1.1 Background

In today's digital era, children are growing up with technology that plays a vital role in their daily lives. Access to educational apps and resources has increased over the years (Subramaniam, 2023), but personalised educational and emotional support catered to their developmental needs is still lacking (Dumont & Ready, 2023). During their developmental years, children often encounter challenges like inadequate guidance, difficulty with learning concepts, and a lack of emotional support (Graziano et al., 2006). In order to overcome these obstacles, this project suggests Jang, an interactive mini robot companion driven by AI. Jang wants to provide kids an engaging, empathetic, and educational companion by fusing conversational AI with emotional intelligence.

1.2 Problem Statement

With the growing reliance on digital content and increasing screen time (Muppalla et al., 2023), children require more engaging, supportive, and constructive interactions with technology. Traditional educational apps often prioritise academic learning, while neglecting emotional engagement and personalised support, leaving critical gaps in their effectiveness. These apps rarely account for a child’s emotional state and many lack parental oversight. This project seeks to bridge these gaps by developing a personalised AI companion that not only supports educational growth, but also provides much-needed emotional support and fostering a stronger connection between children and technology.

1.3 Scope

This project focuses on developing an AI-based educational and emotional support system for children aged 6-8, implemented as a voice-interactive prototype named Jang. The system emphasizes natural spoken interaction, where the child communicates with Jang using voice only, and receives voice-based responses generated based on emotion detection and intent recognition.

Jang uses a machine learning model to classify the emotional tone of user input (e.g., happy, sad) and responds accordingly using a rule-based dialogue engine. The system runs locally on a Raspberry Pi 4 and integrates voice recognition, a basic emotion classifier, text-to-speech output, and a web-based backend interface. For privacy, usability and interaction flow, only audio interaction with the child is implemented, and no facial recognition features are included.

The study specifically focuses on evaluating system usability from an end-user perspective, rather than measuring technical performance metrics such as latency benchmarks or memory optimization. Additionally, Bluetooth-based mobile parental control, offline speech recognition, and dynamic learning content are acknowledged as potential features but are excluded from this version of the system. The project scope is intentionally limited to ensure focus on delivering a functioning, usable prototype that demonstrates core AI-driven interaction principles for children.

1.4 Objectives

i. Design an AI-powered educational and emotional support buddy tailored to children's cognitive and emotional needs.

ii. Develop a functional prototype of the AI Buddy, integrating personalised educational content and emotion recognition.

iii. Evaluate the system's usability to ensure that it provides an intuitive, engaging, and user-friendly experience for children.

1.5 Brief Methodology

This project will utilise the Rapid Application Development (RAD) methodology. The RAD model is a form of agile methodology that focuses on continuous iterations and prototypes based on user feedback, allowing updates to be implemented based on usage rather than following a strict development plan (Egeonu, 2022).

i. Phase 1 - Requirements Planning

- Hardware Requirements: Select appropriate components for Jang, such as a compact processor (e.g., Raspberry Pi, Arduino), cameras for facial recognition, microphones for voice input, speakers for audio output, and sensors for interaction (e.g., touch, proximity). Determine power supply needs and mobility requirements (stationary or moving).
- Software Requirements: Define AI functionalities, including NLP for conversational abilities, emotional detection through sentiment analysis, and interactive educational modules.

ii. Phase 2 - User Design

- Hardware Design: Find a customisable premade robot.
- UI/UX Design: Develop a simple, engaging interface for Jang's interactions, combining voice, gestures, and a small display for visual feedback.

iii. Phase 3 - Rapid Prototyping

- Hardware Prototyping: Assemble a basic robot using selected components, ensuring functionality in movement, input/output, and structural stability.
- Software Prototyping: Develop and integrate Jang's conversational AI, emotional recognition, and educational content modules. Test basic functionalities such as speech recognition, facial detection, and interactive responses.
- Iterative Testing: Gather feedback from target users (children, educators, and parents) to refine both hardware and software.

iv. Phase 4 - Testing and Iteration

- Hardware Testing: Evaluate durability, safety, and responsiveness of physical components under real-world conditions. Test sensor accuracy and mobility features.
- Software Testing: Assess the effectiveness of Jang's AI in providing personalized educational content and detecting emotional cues. Conduct usability testing to ensure smooth and intuitive interactions.
- Integrated Testing: Test hardware and software as a unified system, focusing on seamless interaction between components.

v. Phase 5 - Deployment and Evaluation

- Deploy Jang as a mini robot in classroom and home environments for trial runs to collect feedback on ease of interaction, educational impact on children's learning progress, and emotional support effectiveness. Hardware and software are refined based on trial results.

1.6 Significance of Project

This project offers significant potential to improve children's educational experiences by offering personalised tutoring based on their individual requirements, as well as emotional support and companionship that builds resilience. Additionally, the development of an AI-powered mini robot, Jang, demonstrates innovative applications of technology in child-focused fields, emphasising the viability and value of AI systems in education and emotional growth.

1.7 Expected Outcome

This project aims to deliver a functional prototype of Jang, the mini robot AI Child Buddy, capable of providing personalised educational content and offering emotional support through effective recognition and adaptive responses. Jang will create an engaging and relatable learning experience for children, fostering both cognitive and emotional development. The project’s success will be measured through positive feedback from children, parents, and educators on usability, engagement, and educational impact, ultimately making a significant contribution to the field of AI in education.

1.8 Project Schedule

Table 1.1 Proposed Project Schedule

Phase	Date
Requirements Planning	December 2024
User Design	January 2024
Rapid Prototyping	February-March 2025
Testing and Iteration	April-May 2025
Deployment and Evaluation	June 2025

1.9 Summary

The first chapter provides an overview of the project's background, scope, objectives, and expected outcomes. It highlights the need for an AI-powered educational and emotional support system tailored for children, addressing the gaps in traditional digital tools that lack personalisation and emotional engagement. This chapter introduces Jang, the AI Child Buddy, as a solution to these challenges and outlines the project's methodology, which follows the Rapid Application Development (RAD) approach. By focusing on system usability, this project aims to deliver an innovative, functional prototype capable of fostering children's cognitive and emotional development.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Chapter 2 provides an overview of the literature relevant to the development of Jang, the AI Child Buddy. It explores similar existing systems, methodologies, and tools related to AI in education, emotional support systems, usability for children, and cultural relevance in technology. The aim is to identify the strengths, weaknesses, and gaps in current systems to justify the proposed project and define its unique contributions.

Today, artificial intelligence has revolutionised educational systems. Whether its introducing adaptive learning platforms, virtual tutors, or gamified applications, engagement and learning outcomes are enhanced. Machine learning is used by AI-based platforms like Khan Academy and Coursera to tailor learning programs according to user performance (Song et al., 2024). Studies by Zawacki-Richter et al. (2019) have shown that such platforms can significantly improve learning efficiency by customising educational content according to individual needs. However, while these systems excel in delivering such content, they often lack the ability to provide emotional support or cultivate human-like interactions, which are essential for younger learners.

2.2 Review on Similar Existing Systems

This section reviews three existing systems/tools that are relevant to the proposed project, focusing on their methodologies, technologies, and functionalities. The analysis highlights their strengths and weaknesses in relation to Jang, specifically addressing their suitability for providing personalised educational and emotional support for children.

2.2.1 System 1 – Duolingo

Duolingo is an AI-powered language learning platform that personalises learning paths based on user progress. Website: https://www.duolingo.com/

Table 2.1 Review on Duolingo

Strengths	Weaknesses	Relevance to the Project
• Adaptive learning using AI and gamification to maintain user engagement. • User-friendly interface suitable for children and adults. • Real-time feedback and rewards for motivation.	• Focuses solely on language learning, lacking emotional support. • Limited to specific subject matter, not customisable for broader educational content.	Duolingo demonstrates the potential of gamified learning for engagement but lacks the emotional intelligence and multifunctionality required for Jang.

2.2.2 System 2 – Woebot

Woebot is an AI-powered emotional support chatbot designed to assist users with mental health.

Website: https://woebothealth.com/

Table 2.2 Review on Woebot

Strengths	Weaknesses	Relevance to the Project
• Leverages Natural Language Processing (NLP) to detect user emotions and provide empathetic responses. • Offers cognitive behavioural therapy (CBT) techniques to support emotional well-being.	• Limited functionality for educational content. • Targeted primarily at adults, with minimal consideration for children's cognitive development.	Woebot's emotional recognition capabilities inspire the development of Jang but require adaptation for children's emotional needs and cultural contexts.

2.2.3 System 3 – Pleo the Robot

Pleo is a robotic pet designed for interactive play, learning, and companionship. Website: https://robotsguide.com/robots/pleo

Table 2.3 Review on Pleo

Strengths	Weaknesses	Relevance to the Project
• Provides interactive engagement through physical and emotional expressions. • Encourages creativity and play-based learning.	• Lacks educational functionalities. • Limited adaptability for personalised content.	Pleo's interactive and playful design is an inspiration for Jang's interface and engagement strategies. However, Jang will include additional educational and features.

2.3 Comparison of Features between the Existing Systems

Table 2.4 Comparison of Features between Duolingo, Woebot, Pleo, and Jang.

Feature	Duolingo	Woebot	Pleo	Jang (Proposed)
Personalised Education	Yes	No	Partial	Yes
Emotional Recognition	No	Yes	Partial	Yes
Engagement/Play Features	Partial	No	Yes	Yes
Usability for Children	Partial	No	Yes	Yes

2.4 Discussion of Features in Existing Systems

The review of existing systems identifies strengths and weaknesses that can guide Jang's development. Features such as adaptive learning and gamification from Duolingo, emotion recognition and empathetic responses from Woebot, and interactive engagement from Pleo will be adopted. Improvements that can done include integrating education and emotional support into a single cohesive system and designing an interface tailored to children's cognitive abilities to create an intuitive and engaging user experience.

Based on Table 2.4, Jang will have 4 main functionalities, which are personalised education, emotional recognition, engagement features, and usability for children. Other functions will be further clarified in the next chapter.

2.5 Summary

In this chapter, existing AI systems in education and emotional support were reviewed, focusing on their strengths, weaknesses, and relevance to Jang. The analysis covered Duolingo, Woebot, and Pleo, highlighting their effectiveness in adaptive learning, emotion recognition, and interactive engagement, respectively. However, these systems lack full integration of both educational and emotional support in a single platform, a gap that Jang aims to fill. By leveraging insights from these systems, Jang benefits from proven AI techniques like personalised learning paths, sentiment analysis, and interactive gamification, while also addressing their limitations. Unlike existing solutions, Jang will focus on system usability, ensuring that children find it intuitive, engaging, and effective. The project improves upon current technologies by combining adaptive learning, emotionally intelligent interactions, and parental monitoring, creating a more comprehensive support system for children.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter focuses on the requirements analysis and design aspects. It outlines the methodology used to gather system requirements, identifies the functional and non-functional requirements, and provides a detailed system design. The purpose is to make sure the project aligns with the objectives, delivering a user-friendly AI companion tailored for children's educational and emotional needs, through the Rapid Application Development (RAD) approach.

3.2 Methodology

Methodology is defined as a body of methods, rules, and postulates employed by discipline ("Methodology," 2024). The methodology chosen is Rapid Application Development (RAD) in this project. According to Chien (2020), RAD is a methodology that focuses on developing applications rapidly through frequent iterations and continuous feedback. The reason for choosing RAD is working prototypes can be quickly created and shared, allowing functionality to be reviewed earlier in the software life cycle. The frequent iterations and feedback approach allow every aspect to be easily evaluated, enabling measurable progress that determine if schedule is on track (Chien, 2020).

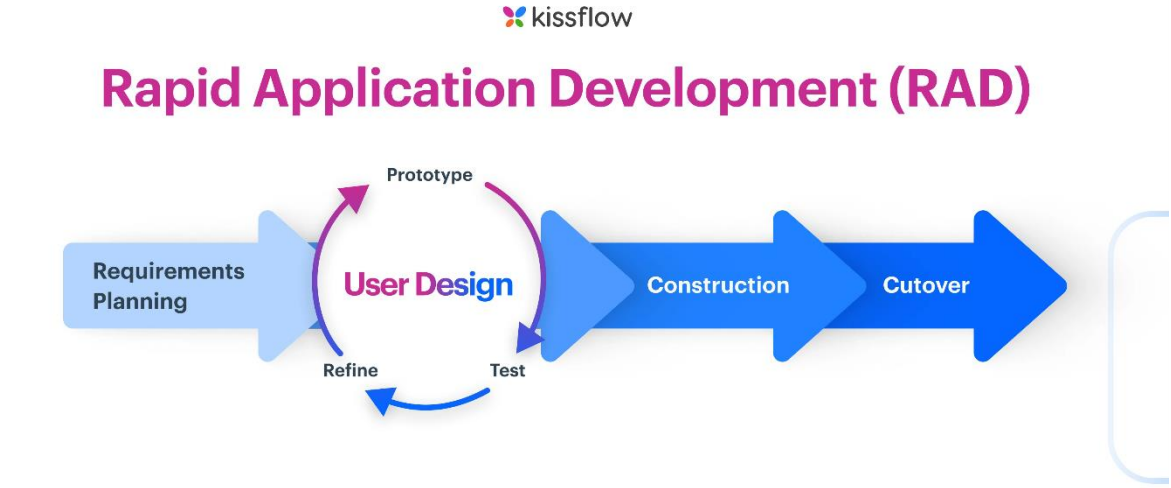

Figure 3.1 Rapid Application Development Model

The RAD model follows a cyclical process that includes four phases: requirements planning, user design, construction, and cutover. User design is an iterative cycle that consists of three sub phases: prototype, test, and refine. All phases in RAD will be described in detail.

3.2.1 Requirements Planning

The first phase in the Rapid Application Development model is requirements planning, where the initial stage of development takes place.

3.2.1.1 Method for Gathering Requirements

The requirements for the proposed system were collected in two ways. Questionnaires were distributed to gather feedback on desired functionalities and features. As mentioned in the previous chapter, existing related AI systems such as Duolingo, Woebot, and Pleo were analysed and reviewed to identify strengths, weaknesses, and potential improvements for Jang.

3.2.1.2 Questionnaire

A survey was conducted by distributing questionnaires to 20 random adult respondents. The purpose is to gather feedback on desired functionalities and features for Jang, the AI Child Buddy. The questionnaire can be referred to in Appendix A. Figure 3.2 below shows that majority of respondents are parents, followed by educators (teachers) and guardians.

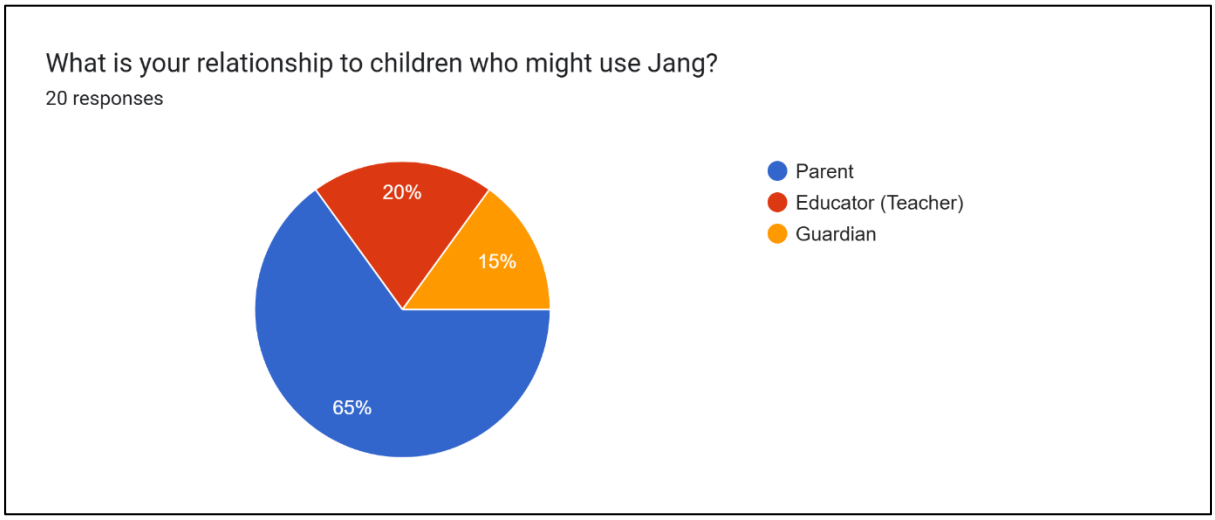

Figure 3.2 Statistic of respondents' relationship to children who might use Jang

Figure 3.3 below shows the age group of the respondents' children, where the children mostly belong to the 3–5 years and 6–8 years age groups, with fewer in the 9–12 years group.

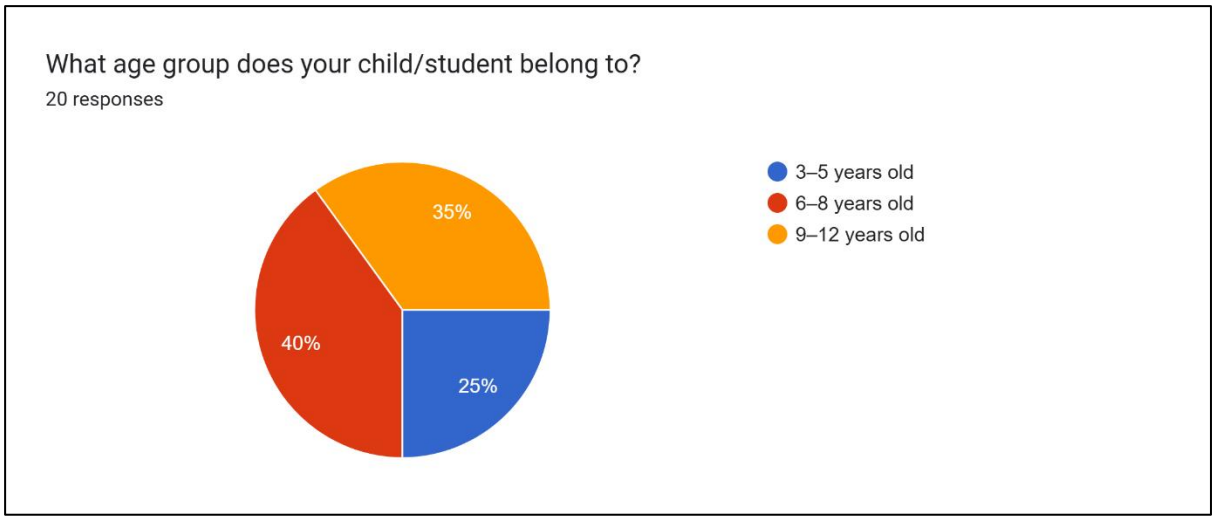

Figure 3.3 Statistic of respondents' children age group

Figure 3.4 below shows the respondent's familiarity with educational or emotional support apps/tools for children. Most respondents are somewhat familiar with these tools, while a few are not familiar at all.

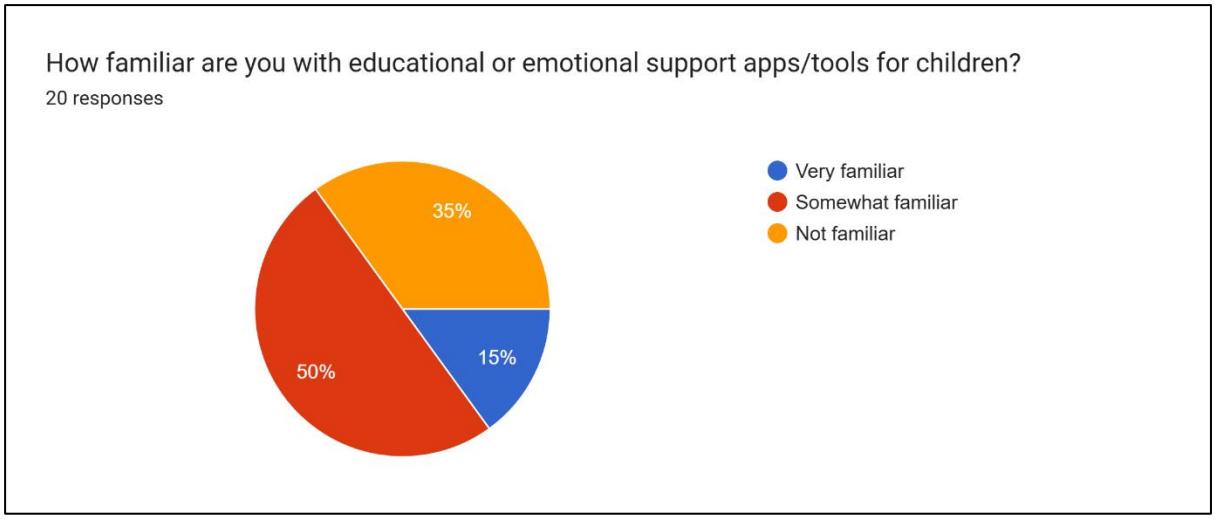

Figure 3.4 Respondent's familiarity with educational/emotional support tools for children

Figure 3.5 below shows the types of educational content that the respondents find most valuable. Popular choices include storytelling and reading activities, math problem-solving games, science-based interactive lessons, and language learning.

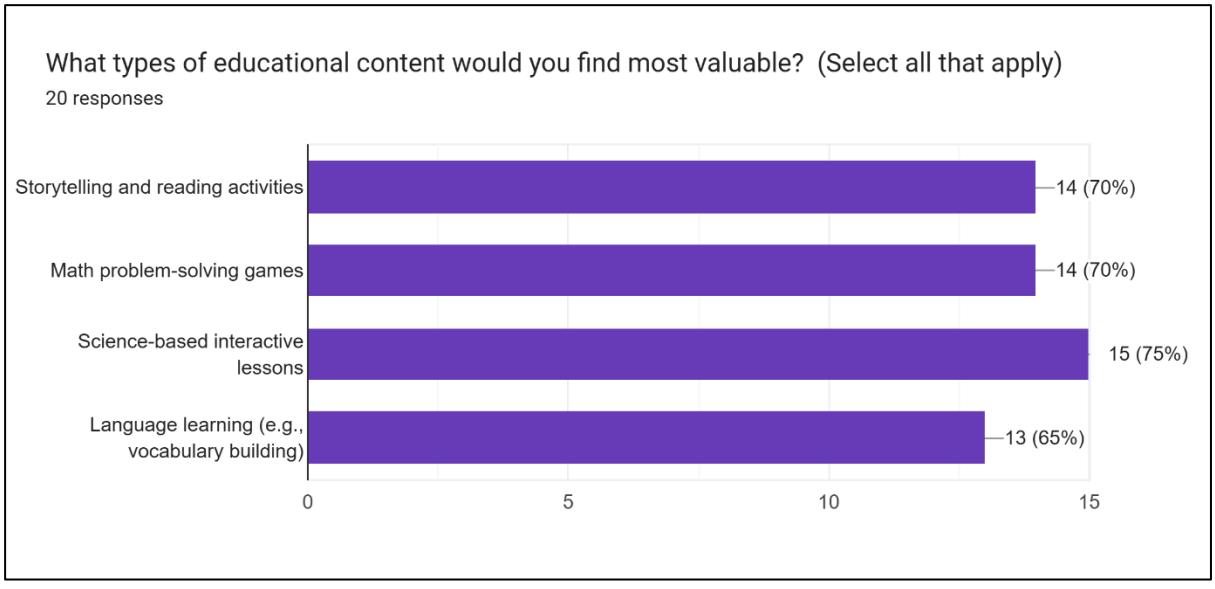

Figure 3.5 Statistic of educational content type that respondents find most valuable

Figure 3.6 below shows respondents' opinion on the importance of the AI's adaptability to a child's progress and learning preferences. On a scale of 1-5, the majority rated this as very important (5), indicating a strong preference for adaptive learning.

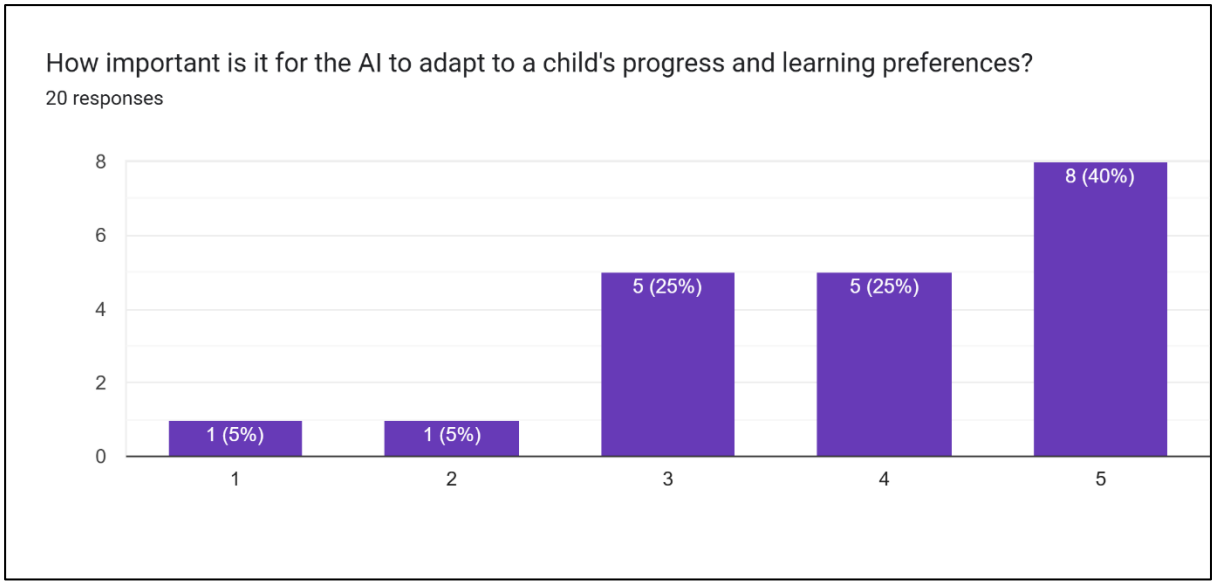

Figure 3.6 Statistic of AI's adaptability importance to progress and learning preferences

Figure 3.7 below shows emotional support features that respondents would like to have on Jang. Common features include comforting responses when the child is upset, motivational encouragement, and recognising signs of frustration.

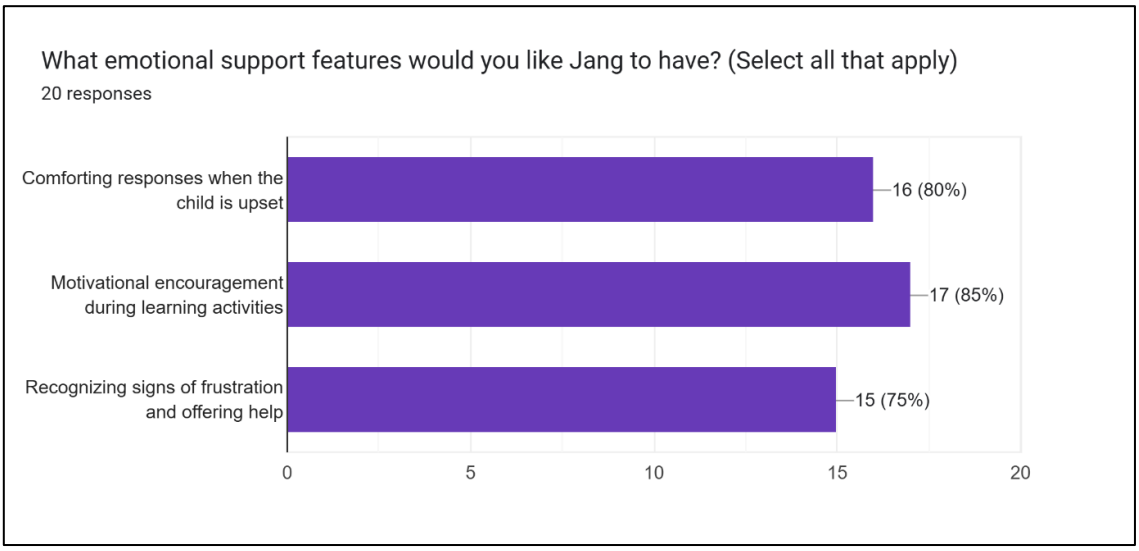

Figure 3.7 Statistic of emotional support features of Jang

Figure 3.8 below shows respondents' opinion on the importance of interactive activities integration like games and quizzes to sustain engagement. On a scale of 1-5, most respondents rated the integration of interactive activities like games and quizzes as very important (5).

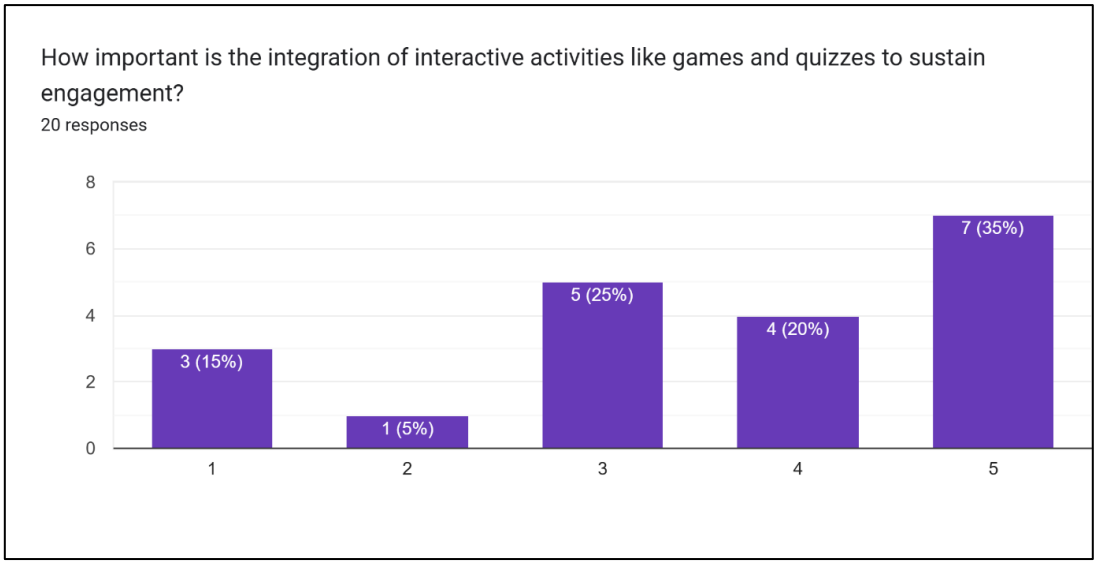

Figure 3.8 Statistic of importance of interactive activities integration to sustain engagement

Figure 3.9 below shows respondents' thoughts on children's preferred forms of interaction. Voice-based conversations and visual displays (e.g., animations) are the preferred forms of interaction for children.

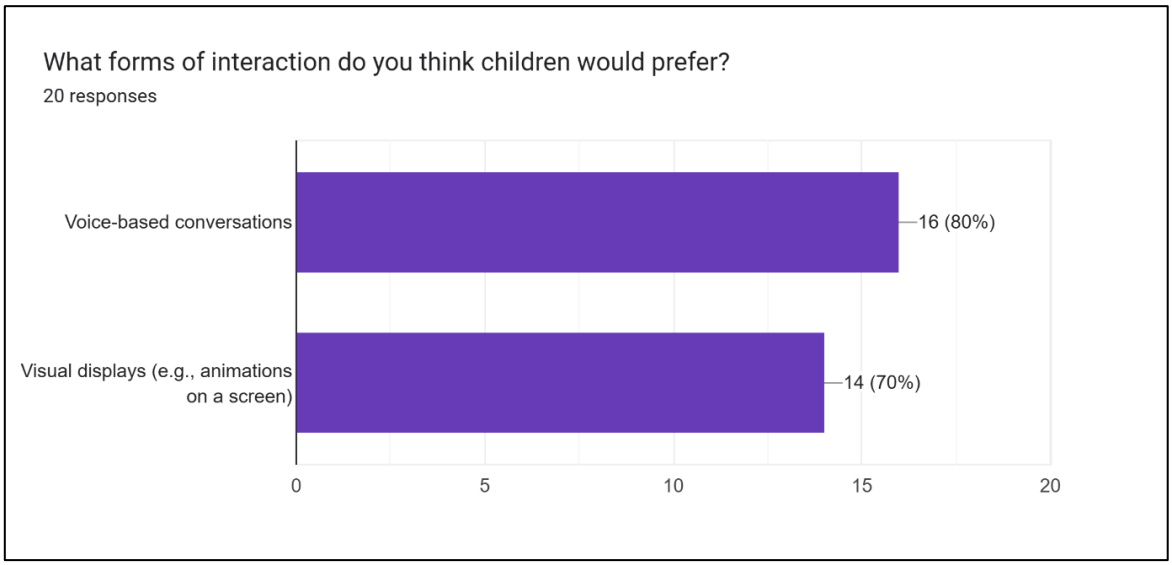

Figure 3.9 Statistic of children's preferred forms of interaction

Figure 3.10 below shows important parental control features according to respondents. Key features include content filtering, activity monitoring reports, setting time limits, and customising educational content.

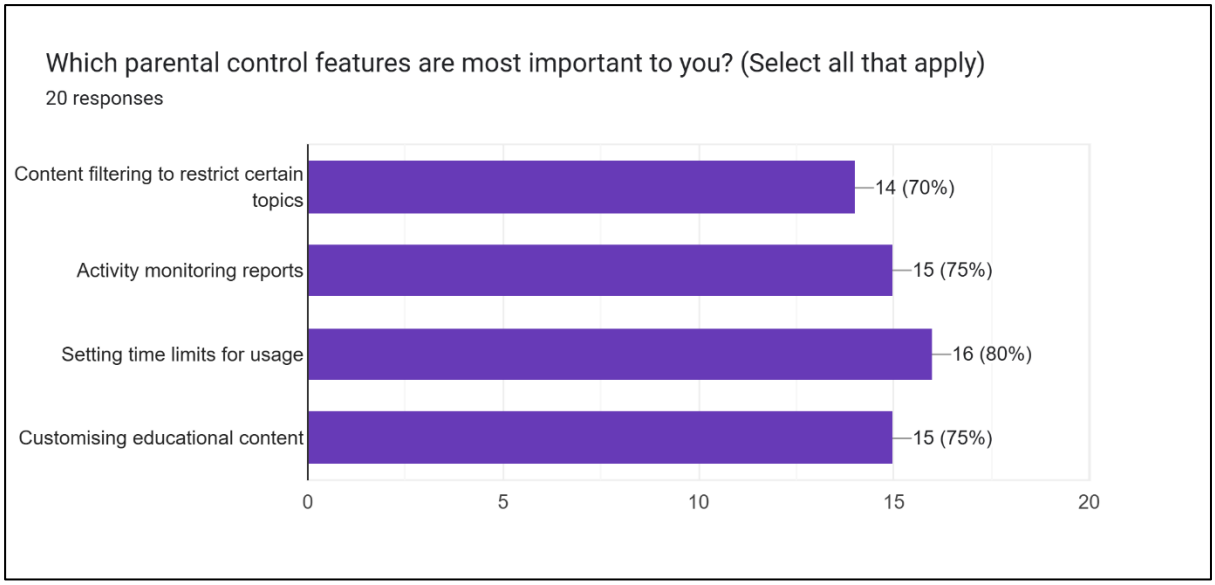

Figure 3.10 Statistic of parental control features

Figure 3.11 below shows respondents' preference to access the parental control features. Most respondents prefer using mobile app to monitor and manage their child's experience with Jang.

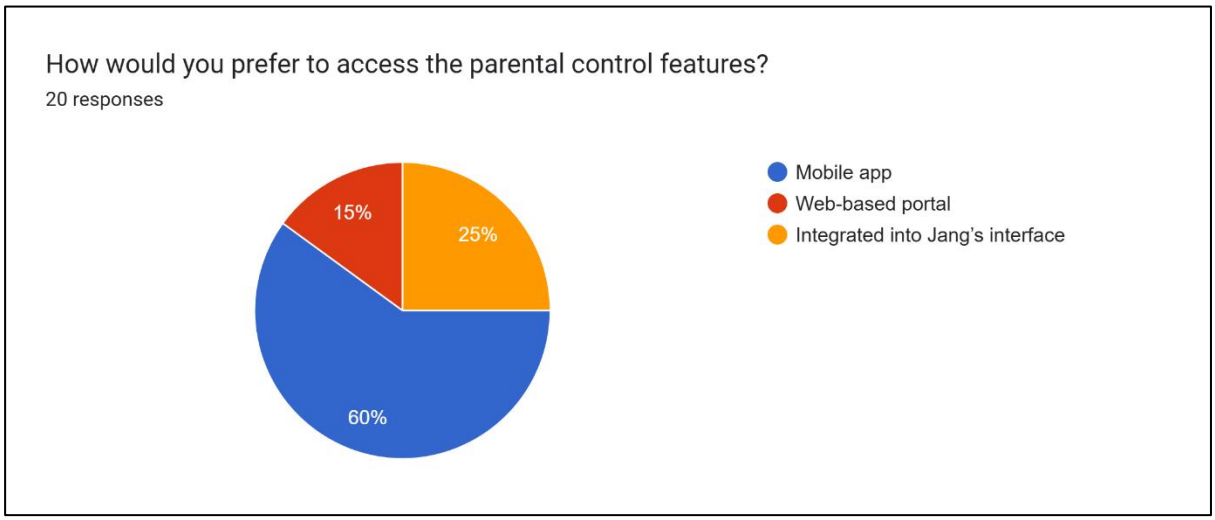

Figure 3.11 Statistic of preference to access parental control features

Figure 3.12 below shows respondents' design choice of Jang that is the most appealing for children. Preferences vary from simple, minimalistic designs to bright colours and playful animations, and themes based on popular characters. It was determined that bright colours and playful animations is the most engaging.

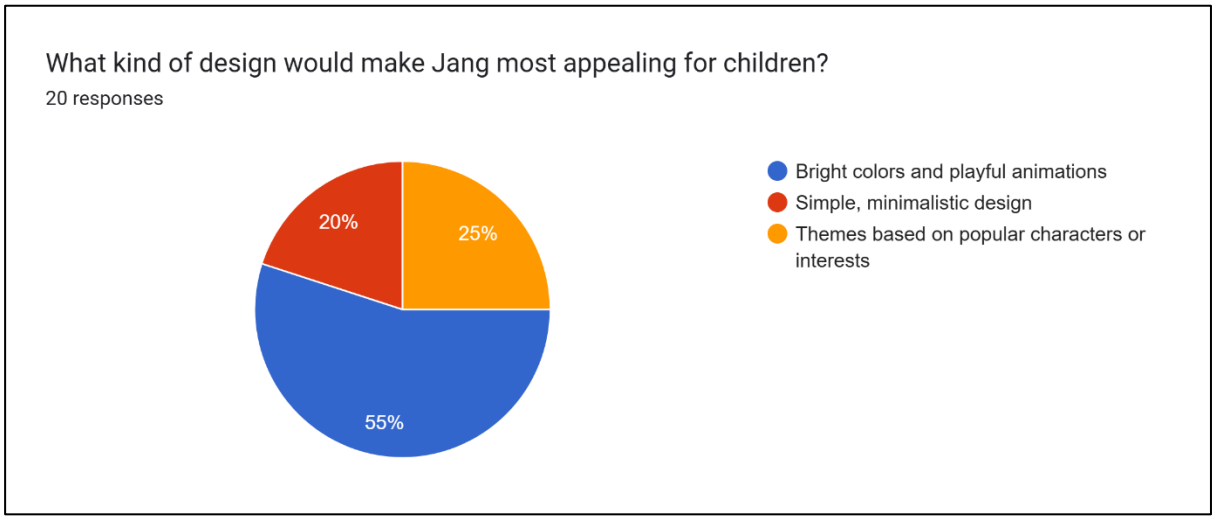

Figure 3.12 Statistic of most appealing design for children

Figure 3.13 below shows the most important usability features for a child-friendly interface. Easy-to-navigate menus, voice-based guidance, and large buttons and icons are crucial for a child-friendly interface.

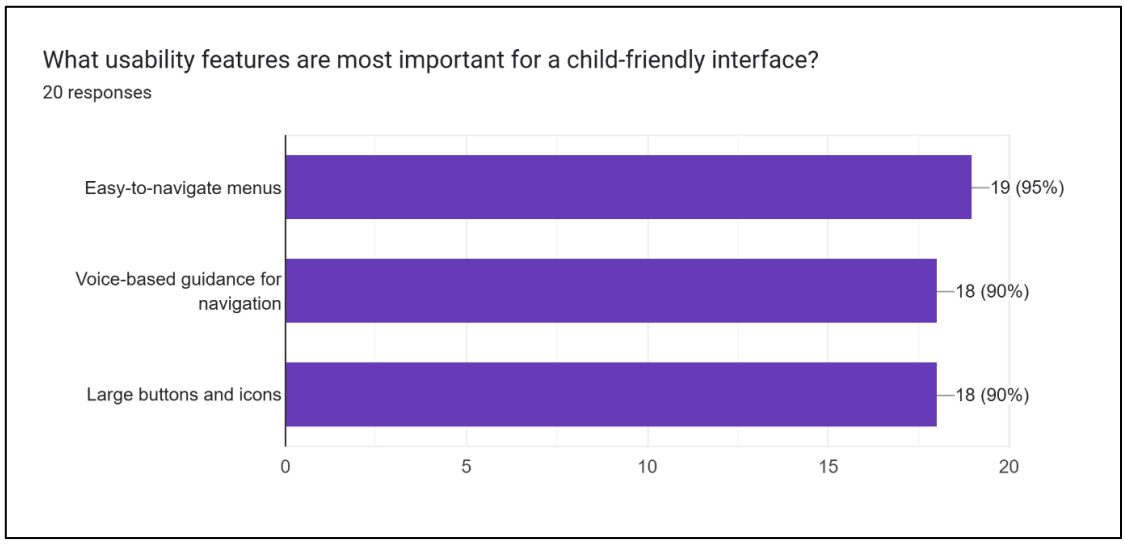

Figure 3.13 Statistic of usability features for a child-friendly interface

Lastly, some respondents also provided feedback and additional suggestions. Table 3.1 below shows the summary. These will be considered during the development of Jang.

Table 3.1 Summary of respondents' feedback and additional suggestions

No.	**Concerns**	**Additional features or functionalities**	**Other feedback or suggestions**
1	Durability of Jang	Bedtime mode (bedtime stories, soothing sounds)	Provide a way for parents to set up specific learning goals or milestones
2	Children might become overly dependent on Jang for emotional support	Offline functionality for areas with limited internet connectivity	Regular software updates to introduce new activities and fix bugs
3	Sensitive emotional data and its compliance with privacy regulations	Provide daily summary of children's learning progress to parents	Adaptive responses to different voice tones or non-verbal cues like long pauses
4	The need for constant internet connectivity and what happens during outages.	Visual appealing but not too overly flash or distracting	Integrating Jang with existing smart home systems for more utility
5		Multilingual feature	
6		Reward system to encourage children to engage more with educational activities	

3.2.1.3 Functional requirements of Jang

i. **Personalised Education:** Jang should provide interactive and adaptive educational content tailored to the child's progress and learning preferences.

Implementation:

- **AI Learning Engine:** Uses machine learning models to adapt educational content based on the child's progress and performance.
- **Content Management System (CMS):** Stores and updates lessons, quizzes, and interactive activities.
- **Speech-to-Text & Text-to-Speech (STT & TTS):** Allows Jang to interact with children through voice-based communication.

ii. **Emotion Detection:** Jang should recognise and respond to children's emotional states using sentiment analysis.

Implementation:

- **Sentiment Analysis:** NLP-based sentiment detection to analyse the child's tone and text input.
- **Voice Emotion Analysis:** Processes tone variations using deep learning models to determine emotional states.
- **Adaptive Response System:** Jang adjusts its tone and interactions dynamically based on detected emotions.

iii. **Interactive Engagement:** Jang should incorporate storytelling, quizzes, and games to sustain user interest and engagement.

Implementation:

- **Conversational AI:** Uses NLP-based chatbot to enable interactive storytelling, quizzes, and educational discussions.

iv. **Speech Interaction:** Jang should be able to have conversational interactions through voice input.

Implementation:

- **Voice Recognition:** Speech-to-text conversion using Google Speech API for processing child's spoken inputs.

v. **Parental Controls:** Jang should have parental controls which allow parents to monitor and customise Jang's functionalities and access usage data.

Implementation:

- **Parental Dashboard:** A web or mobile application that allows parents to monitor Jang's interactions and set usage limits.
- **Usage Reports:** Generates periodic reports summarizing a child's learning progress and emotional trends.

3.2.1.4 Non-functional Requirements of Jang

i. **Usability**: Ensure an intuitive and child-friendly interface that is simple to navigate.

ii. **Performance**: Respond to user inputs within two seconds to maintain smooth interaction.

iii. **Reliability**: Maintain 95% uptime to ensure consistent availability.

iv. **Security**: Protect user data through encryption and compliance with privacy regulations.

v. **Scalability**: Support additional features and increased user interactions without significant performance degradation.

3.2.2 User Design

The user design phase will be carried out following the requirement planning stage. This phase focuses on creating and refining prototypes of Jang to align with user needs. User design

includes three subphases: prototype, test, and refine. They are part of an iterative cycle that will be tested and implemented until it satisfies the needs of the proposed system. Prototyping the architecture of Jang will be the main focus. As the requirements are refined over time, the system will be tested constantly and improved. The process will be repeated as the system evolves. This iterative process ensures the design is both intuitive and engaging, catering to children's cognitive and emotional needs.

3.2.2.1 Prototype

Initial prototypes of Jang are developed to simulate its core functionalities, such as conversational AI, emotional recognition, and interactive educational modules. The prototypes may include but not limited to a draft of the user interface, visual design, and basic hardware integration to provide users with a clear representation of the system's key features.

3.2.2.2 Testing

The prototypes are tested by target users, including children, parents, and educators, to identify potential usability issues and functionality gaps. Feedback on interaction intuitiveness, engagement level, and educational effectiveness is also collected. Observations from these tests may also reveal challenges children may face during interactions, allowing for improvements.

3.2.2.3 Refine

Based on the results of the testing phase, the prototypes are refined to address identified issues. This phase ensures that the design evolves to meet user expectations and aligns with the project's usability goals.

3.2.3 Construction

Next, the construction phase focuses on building the complete system by integrating all its components, including software, hardware, and user interface designs. During this phase, the AI core, such as natural language processing and emotional recognition modules, is implement alongside the educational modules and interaction features. Components such as microphone and speakers are assembled and integrated into the physical hardware too.

Additionally, two types of testing will be conducted. The first is component testing. Each individual feature such as speech recognition or emotion detection is tested independently to ensure proper functionality. The second is system testing. Once all components are integrated, the entire system is tested to confirm smooth interaction between hardware and software. This ensures Jang is both functional and robust, capable of handling real-world usage scenarios.

By the end of this phase, an almost-final version of Jang is ready for deployment, with all major features operational and validated.

3.2.4 Cutover

Finally, the cutover phase is where system development transition to deployment. Jang is introduced into practical environments, such as homes and classrooms, where it interacts with children in its intended use cases. Jang may be deployed in a limited setting first to evaluate its readiness and identify potential adjustments needed.

3.3 System Design

3.3.1 System Architecture

The system follows a modular architecture, with key components divided into:

i. **User Interface (UI):** A child-friendly graphical and conversational interface for interactions.

ii. **AI Core:**

- **Natural Language Processing (NLP) Module:** Processes user inputs and generates responses.
- **Emotion Recognition Module:** Analyses sentiment from text and voice inputs.
- **Learning Engine:** Adapts educational content based on user progress.

iii. **Database:** Stores user data, learning progress, and interaction logs.

iv. **Parental Control Dashboard:** Provide monitoring and customisation features for parents.

3.3.2 Use Case Diagram

Figure 3.14 below illustrates the interactions between users and the system.

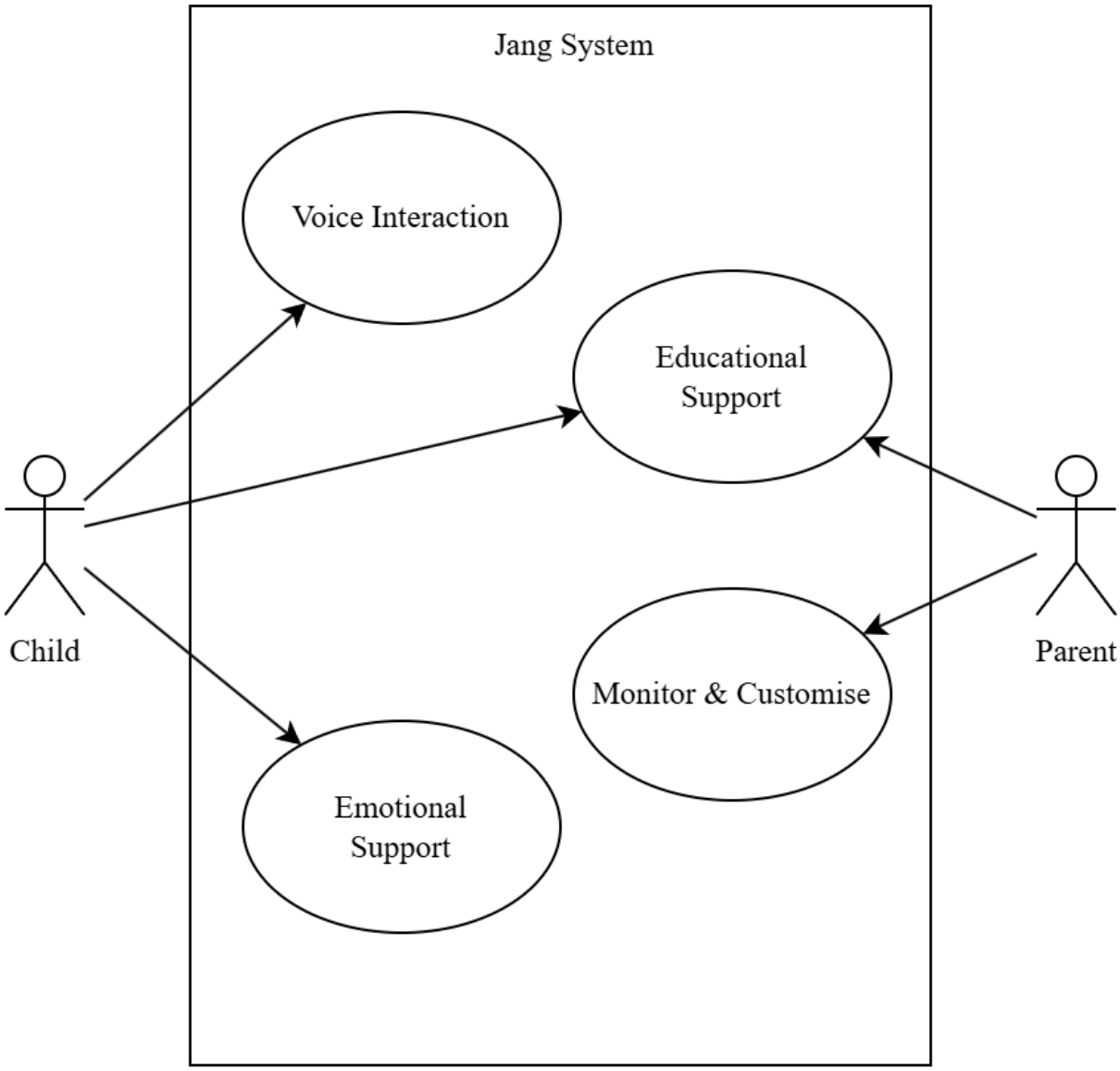

Figure 3.14 Use Case Diagram of Jang System

Actors: Child, Parent.

- The Child interacts with Educational Support, Emotional Support, and Voice Interaction.
- The Parent interacts with Monitor & Customise and can also track Educational Support.

3.3.3 Sequence Diagram

Figure 3.15 below shows how a child interacts with Jang to receive personalised learning content.

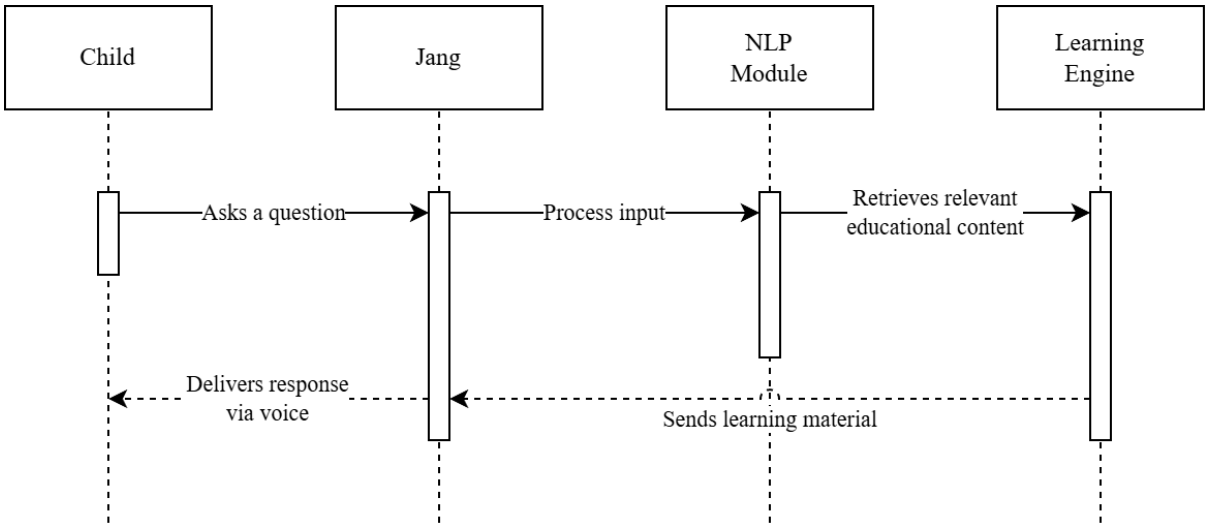

Figure 3.15 Sequence Diagram for Educational Support Interaction

Actor: Child inputs a query (e.g., asks a question).

System Components: The NLP Module processes the input, and the Learning Engine provides an appropriate response (e.g., sends learning material).

Output: Jang generates and delivers the response.

Figure 3.16 below shows how Jang detects and responds to a child's emotional state.

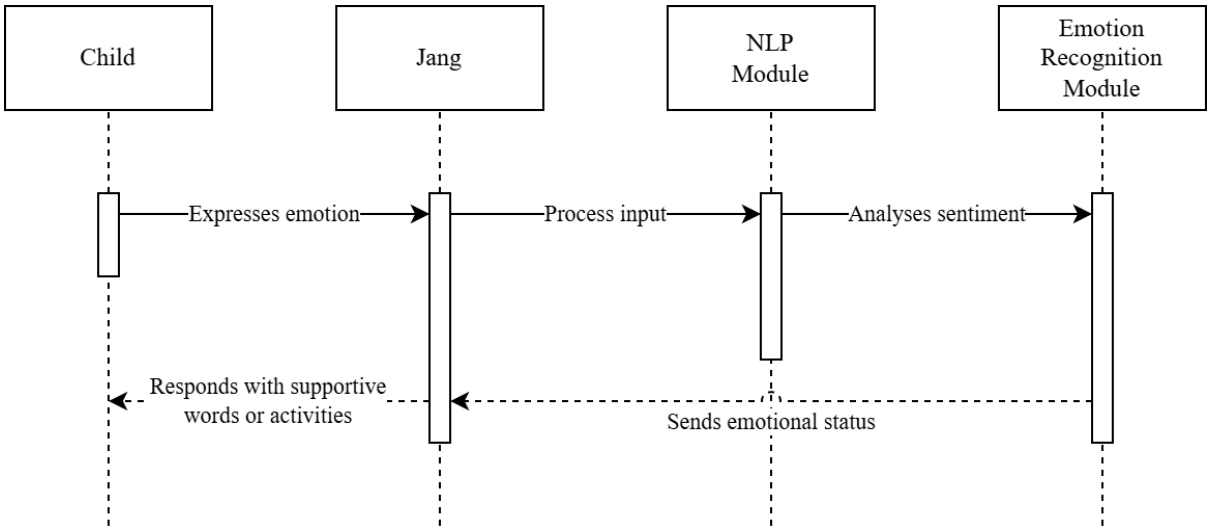

Figure 3.16 Sequence Diagram for Emotional Support Interaction

Actor: Child expresses emotion (e.g., "I feel sad").

System Components: The NLP Module processes the input, and the Emotion Recognition Module provides an appropriate response (e.g., sends emotional status).

Output: Jang generates and delivers the response.

Figure 3.17 below shows how a parent customizes Jang's behaviour and monitors the child's learning.

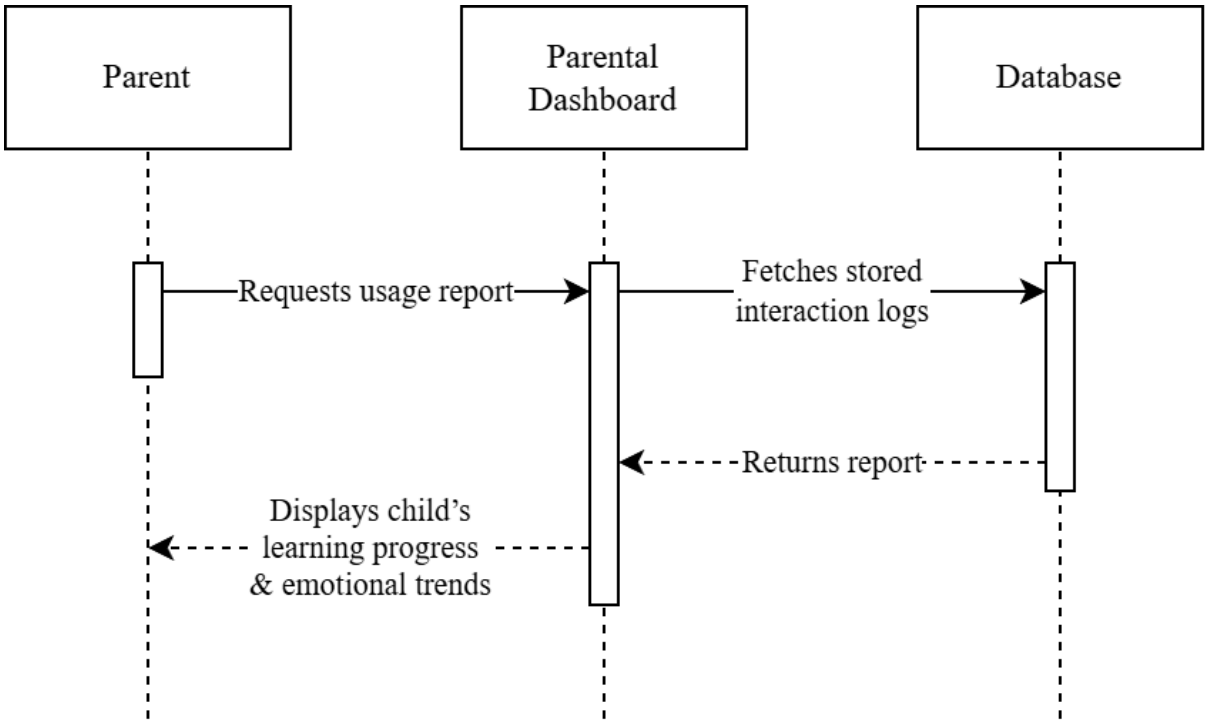

Figure 3.17 Sequence Diagram for Parental Monitoring & Customisation

Actor: Parent requests usage report via app.

System Components: Parental Dashboard fetches stored logs and Database returns information.

Output: Parental Dashboard displays child's educational progress and emotional trends.

3.3.4 Activity Diagram

Figure 3.18 below visualises how Jang processes user interactions and makes decisions within the system to help understand the workflow of Jang.

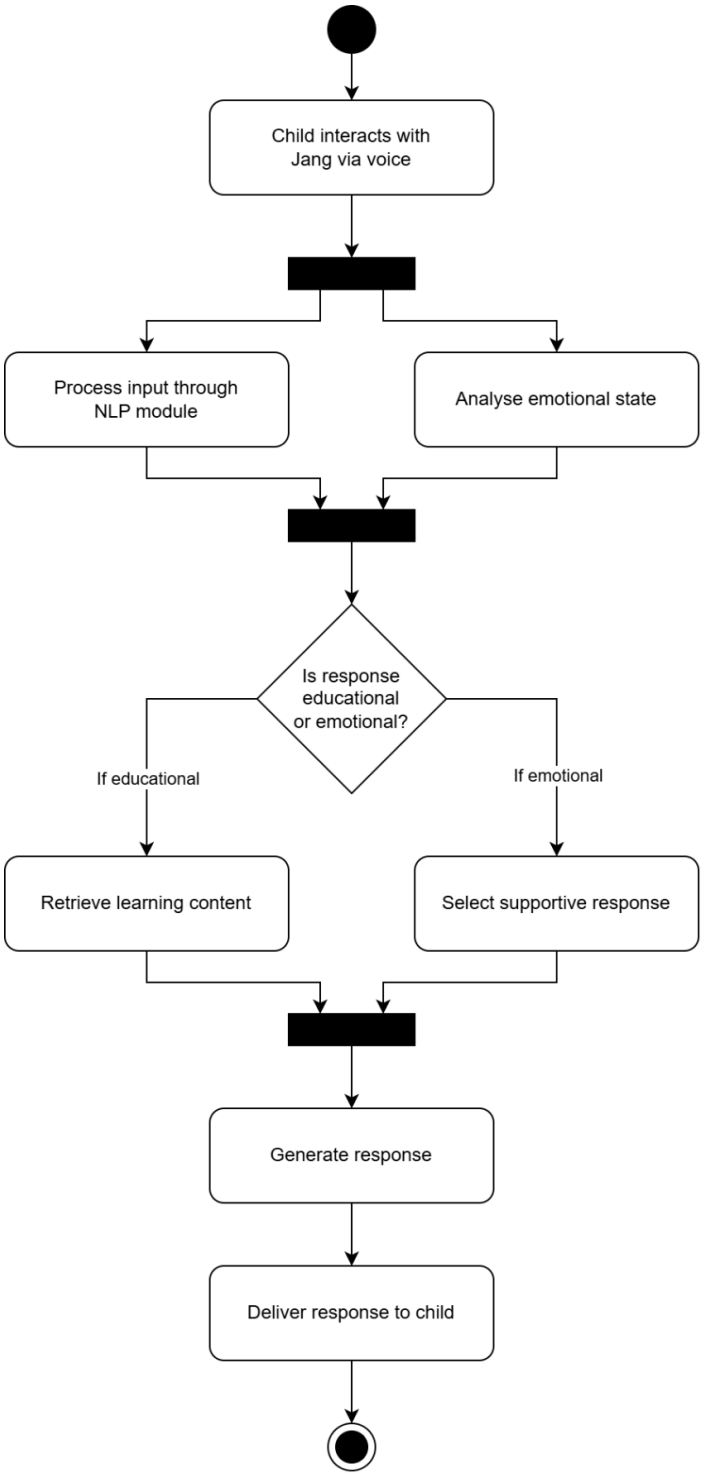

Figure 3.18 Activity Diagram for Jang's System

Start: Child interacts with Jang via voice.

Fork into two processes:

- NLP module processes input.
- Emotion Recognition module detects the emotional state.

Merge back at decision node:

- If educational: Retrieve learning content.
- If emotional: Select supportive response.

Output: Jang generates and delivers the response to child.

End: Interaction logged in the database for analysis and improvement.

3.4 Summary

This chapter outlined the requirement analysis and system design for Jang, the AI Child Buddy. It detailed the methodologies used to gather system requirements. The functional and non-functional requirements were defined to ensure the system meets usability standards.

The system design was presented with key components, including the User Interface (UI), AI Core (NLP & Emotion Recognition), Learning Engine, Database, and Parental Dashboard. Additionally, various UML diagrams, such as the Use Case Diagram, Sequence Diagram, and Activity Diagram, were introduced to illustrate Jang's interactions, workflows, and decision-making processes.

Overall, this chapter provides a clear framework for implementing Jang, ensuring it aligns with the project's goal of delivering an intuitive and effective AI-powered educational and emotional support mini robot for children.

CHAPTER 4: DEVELOPMENT AND IMPLEMENTATION

4.1 Introduction

This chapter presents the implementation of Jang, an AI-powered educational and emotional support system for children. The system is designed to run entirely on a Raspberry Pi 4, operating locally without internet dependency except for speech recognition. It incorporates voice-based interaction, basic emotion detection using a lightweight machine learning model, simple facial animations, and parental monitoring through event logging. The development follows the Rapid Application Development (RAD) approach to ensure iterative design, prototyping, and user-centred improvements.

4.2 Tools and Technologies Used

Table 4.1 Tools and Technologies Used

Component	Technology
Programming Language	Python
Voice Recognition	speech_recognition (Google API)
Text-to-Speech	pyttsx3
Emotion Detection	Scikit-learn + Naive Bayes Classifier
Face Animation	pygame
Parental Monitoring	CSV-based event logging (local file)
Hardware Platform	Raspberry Pi 4

4.3 System Architecture

Jang consists of five primary modules that run on the Raspberry Pi:

1. **Voice Input Module** – Uses a microphone to capture child's voice input and transcribe it into text.
2. **Emotion Detection Module** – Classifies the emotional tone of the text using a trained ML model.
3. **Response Generation Module** – Determines an appropriate reply based on emotion and context.
4. **Face Animation Display** – Shows an animated face expressing Jang's emotional response.
5. **Parental Monitoring Module** – Logs each interaction with a timestamp, detected emotion, and system response to a local file.

4.4 Key Modules

4.4.1 Voice Interaction

Jang uses a USB microphone and the speech_recognition library to capture and convert the child's spoken input into text. The speech is processed in real time and passed to the emotion classifier.

4.4.2 Emotion Detection

The project implements a lightweight Naive Bayes classifier trained on a dataset of short emotional expressions. The classifier categorizes the input into basic emotions such as *happy*, *sad*, *confused*, *angry*, or *scared*.

4.4.3 Response Generation

Based on the predicted emotion, the system generates an appropriate verbal response using conditional logic. For example, a sad input will trigger comforting phrases, while a happy input may lead to playful or congratulatory replies.

4.4.4 Face Animation Display

To visually reflect Jang's emotional responses, a simple digital face is displayed using pygame. The expressions are represented with minimal graphics, such as smiling, or blinking eyes, and change depending on the detected emotion.

4.4.5 Parental Monitoring (Event Logging)

Each user interaction is recorded in a .csv file stored locally. The log includes:

- Timestamp of interaction
- User input (as transcribed)
- Detected emotion
- Jang's verbal response

This allows parents to review past conversations and monitor the nature of the interaction.

4.5 Conclusion

The system was successfully implemented on a Raspberry Pi 4 with five key modules: voice input, emotion detection, response generation, face animation, and event logging. All interactions are handled locally without reliance on web or cloud platforms. The implementation supports the project's goal of creating an emotionally responsive, child-friendly AI companion with a usable and self-contained hardware setup.

CHAPTER 5: TESTING AND EVALUATION

5.1 Introduction

The testing phase is important and is carried out after the implementation phase of each module to make sure that the implementation corresponds with the project requirements. During this stage, a thorough test plan is created, and each component is given a unique test ID to confirm and validate. Functionality testing and non-functionality testing are the two types of testing. Usability testing is covered in full in the section on non-functionality testing. Engaging potential users in usability testing allows them to assess the prototype and see if it meets their expectations. A questionnaire will be sent out following the testing session to collect user input and evaluate usability in more detail.

5.2 Functionality Testing

Tables 5.1 to 5.5 provide an overview of the test cases for each functionality of Jang. These tables provide thorough breakdown of various inputs and scenarios that were tested to guarantee the reliability and robustness of the AI Child Buddy.

Table 5.1 Test Case - Voice Input Recognition

Test ID	**Test Case**	**Input Data (User Phrase)**	**Expected Result**	**Actual Result**	**Pass/Fail**	**Comments**
V-01	Recognize happy phrase	"I'm so happy today!"	Text is accurately transcribed	Correct transcription	Pass	Background was quiet

V-02	Recognize confused phrase	"I don't understand this"	Text is accurately transcribed	Minor stutter but correct	Pass	Recognized well despite stutter
V-03	Background noise rejection	*User says nothing*	No false trigger	No input detected	Pass	Handled noise well

Table 5.2 Test Case - Emotion Detection (ML Model)

Test ID	**Test Case**	**Input Data (User Phrase)**	**Expected Result**	**Actual Result**	**Pass/Fail**	**Comments**
E-01	Detect happiness	"Yay, I did it!"	Emotion: happy	Emotion: happy	Pass	Correct classification
E-02	Detect sadness	"I feel lonely"	Emotion: sad	Emotion: sad	Pass	
E-04	Misclassification check	"I'm tired"	Emotion: sad or neutral	Emotion: neutral	Pass	Acceptable outcome

Table 5.3 Test Case - Response Generation

Test ID	Test Case	Input Data (User Phrase)	Expected Result	Actual Result	Pass/Fail	Comments
R-01	Happy reply	"Yay, this is fun!"	Positive response acknowledging happiness	Responds with fun prompt	Pass	
R-02	Sad reply	"I feel really down today"	Empathetic, comforting response	Offers comfort or cheer	Pass	
R-03	Confused reply	"I don't get it"	Supportive response encouraging clarity	Offers help	Pass	
R-04	Fallback for unknown input	"Pizza is blue"	Default: "Tell me more" style reply	"Tell me more!"	Pass	Handles unrecognized input

5.3 Non-functionality Testing

Table 5.4 Test Case - Non-functionality Testing

Test ID	Test Case	Expected Result	Actual Result
NF-01	**Startup Time**	System boots and is ready to interact within 1 minute	System initializes in ~45 seconds
NF-02	**Response Time**	Jang responds to user input not longer than 2 seconds	Jang responds to user input within 2 seconds
NF-03	**Reliability During Continuous Use**	No crash or freeze after 15-minute continuous voice interaction	Stable during test, no crashes observed
NF-04	**Voice Recognition in Quiet Room**	System accurately recognizes voice commands in a quiet environment	Clear and consistent recognition
NF-05	**Voice Recognition in Noisy Room**	Voice input might degrade slightly, but system still returns valid fallback	Slight accuracy drop but fallback works correctly
NF-06	**Security (Local Operation)**	No sensitive data transmitted or stored externally	All data processed locally; no API keys or cloud usage for TTS
NF-07	**Scalability (Multiple Inputs)**	System handles multiple inputs without crashing or slowing down	Tested up to 10 consecutive inputs — no slowdown

5.3.1 Usability Testing

A total of 10 respondents responded to the usability questionnaire. The questionnaire can be referred to in Appendix B. Each question is rated on a linear scale, from 1 - strongly disagree to 5 - strongly agree. The results have been converted into charts for better visualization.

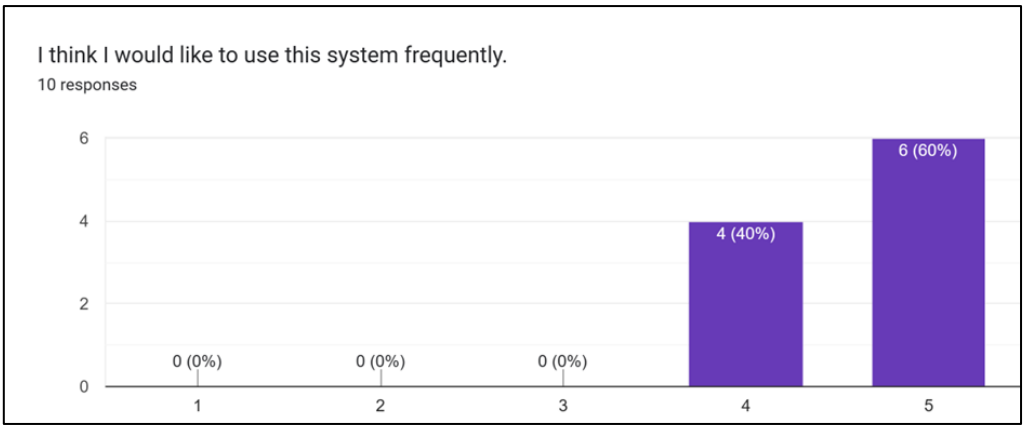

Figure 5.1 User's opinion on using Jang again

In Figure 5.1, respondents showed a strong willingness to reuse the system, indicating overall engagement and positive impression.

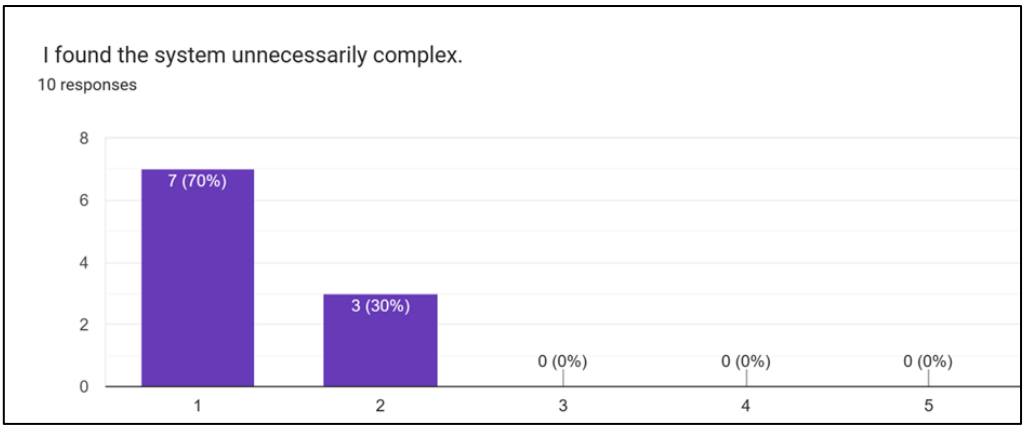

Figure 5.2 User's opinion on the system's complexity

Figure 5.2 indicates the system was perceived as simple and intuitive, with minimal unnecessary complexity.

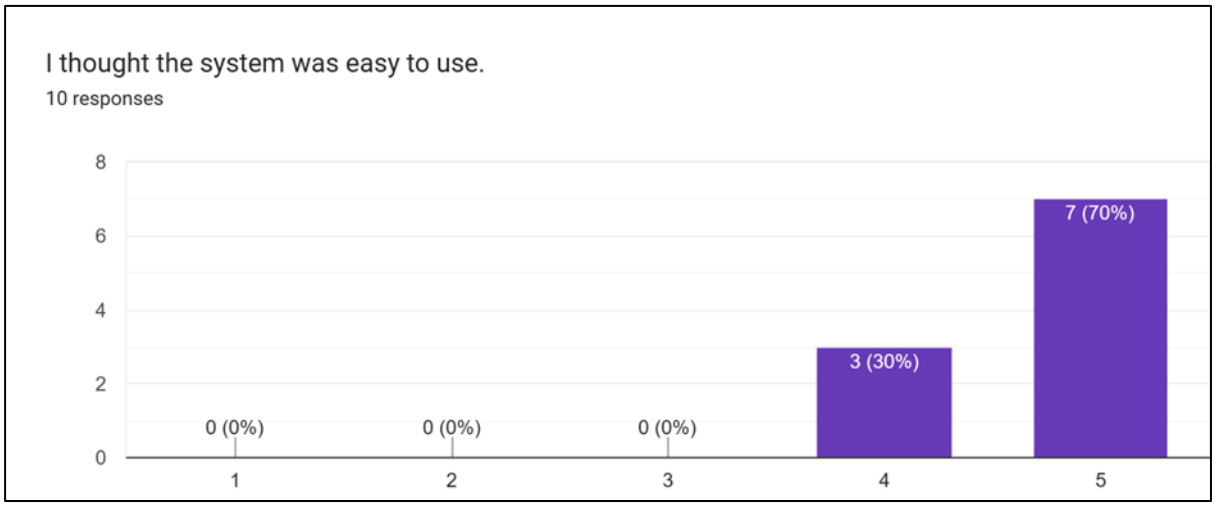

Figure 5.3 User's opinion on ease of use

Figure 5.3 provided clear agreement that the system is easy to use, even for first-time users.

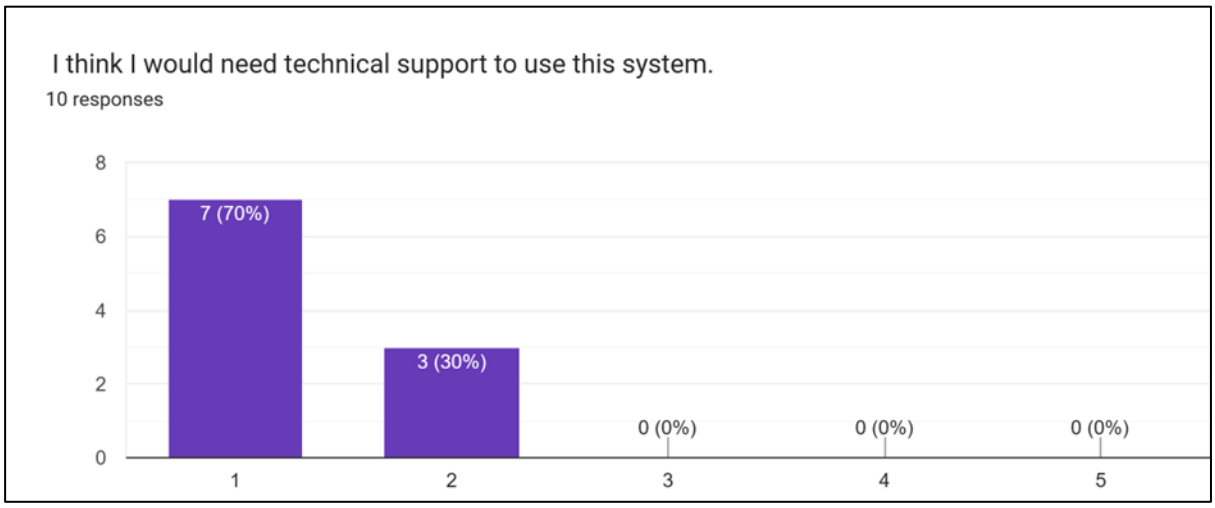

Figure 5.4 User's opinion on the need of technical support

Figure 5.4 shows strong consensus that the system is self-explanatory and doesn't require external help.

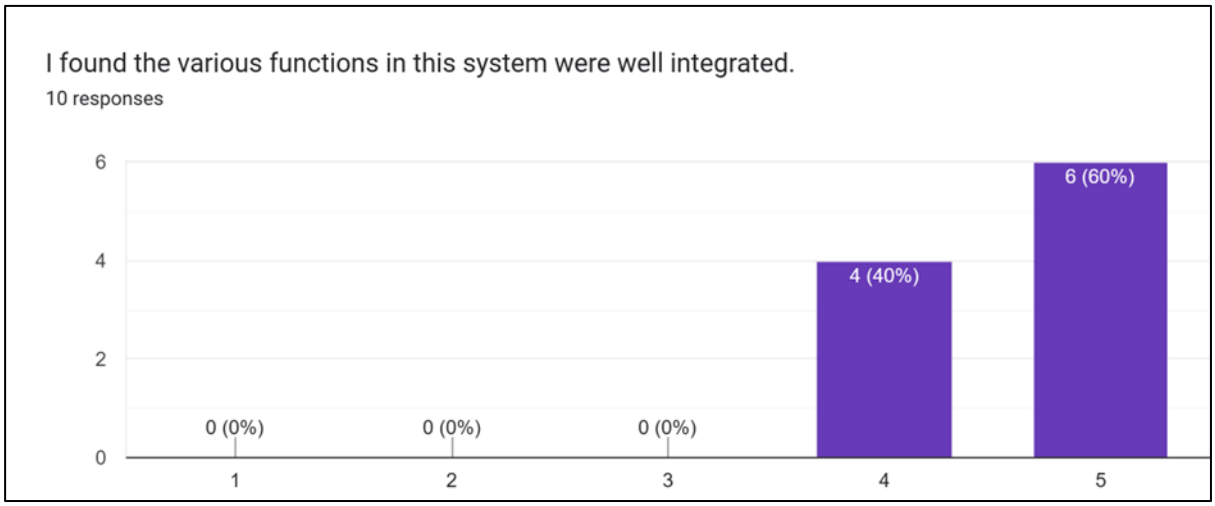

Figure 5.5 User's opinion on system integration

Figure 5.5 suggests that the various features (voice input, response, TTS, etc.) work smoothly together without confusion.

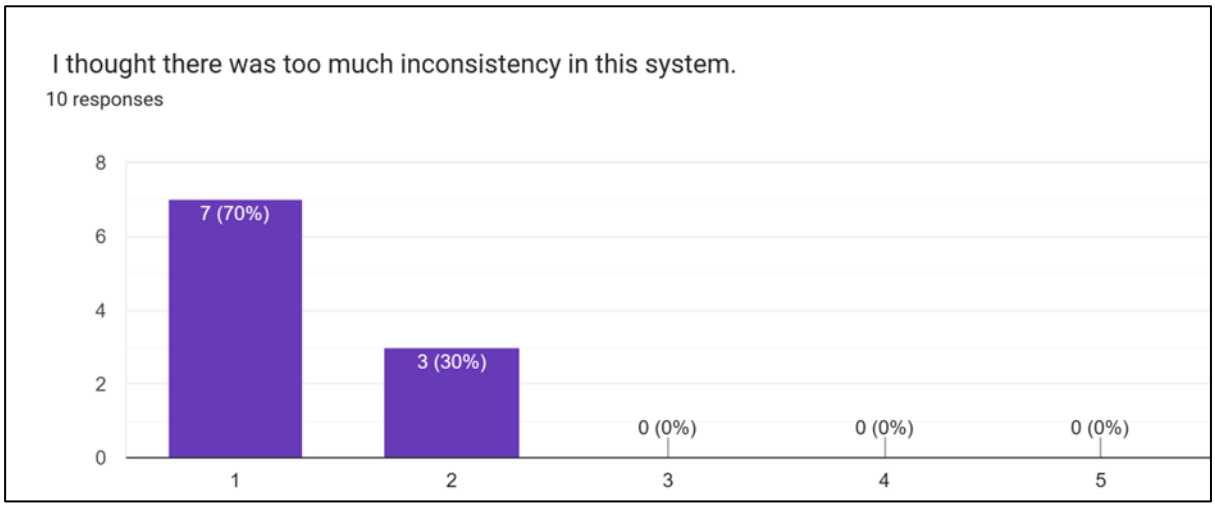

Figure 5.6 User's opinion on system inconsistency

Figure 5.6 shows that users found the system behaviour consistent, reliable, and predictable.

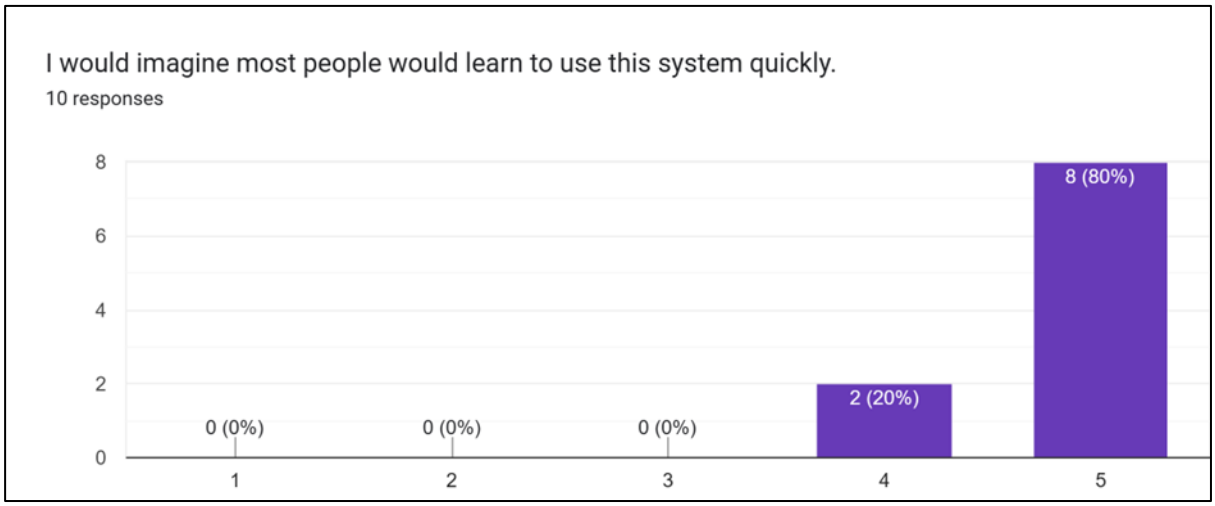

Figure 5.7 User's opinion on if the system is fast to learn

Figure 5.7 indicates excellent learnability, suitable for non-tech-savvy users such as parents or children.

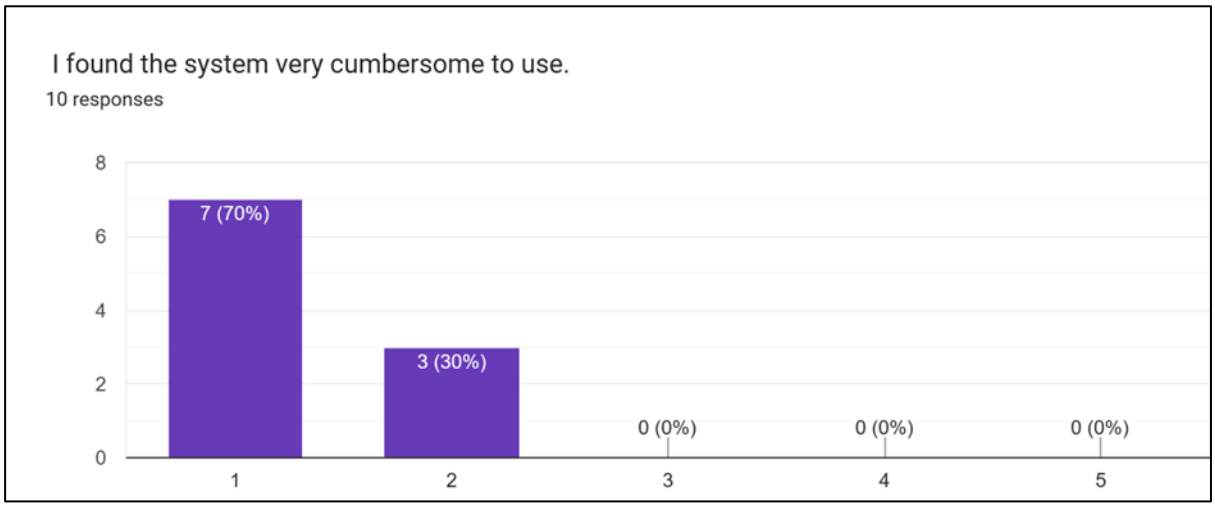

Figure 5.8 User's opinion on if Jang is troublesome to use

Figure 5.8 shows that users didn't find the system burdensome or frustrating.

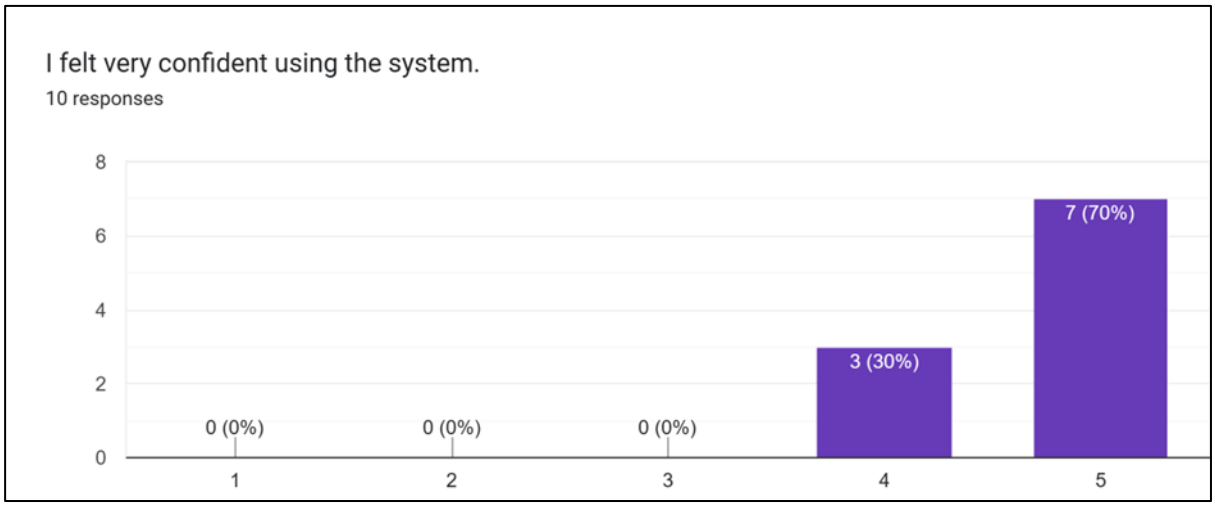

Figure 5.9 User's confidence using the system

Figure 5.9 shows that respondents gave positive feedback about system comfort and confidence, even with voice interaction.

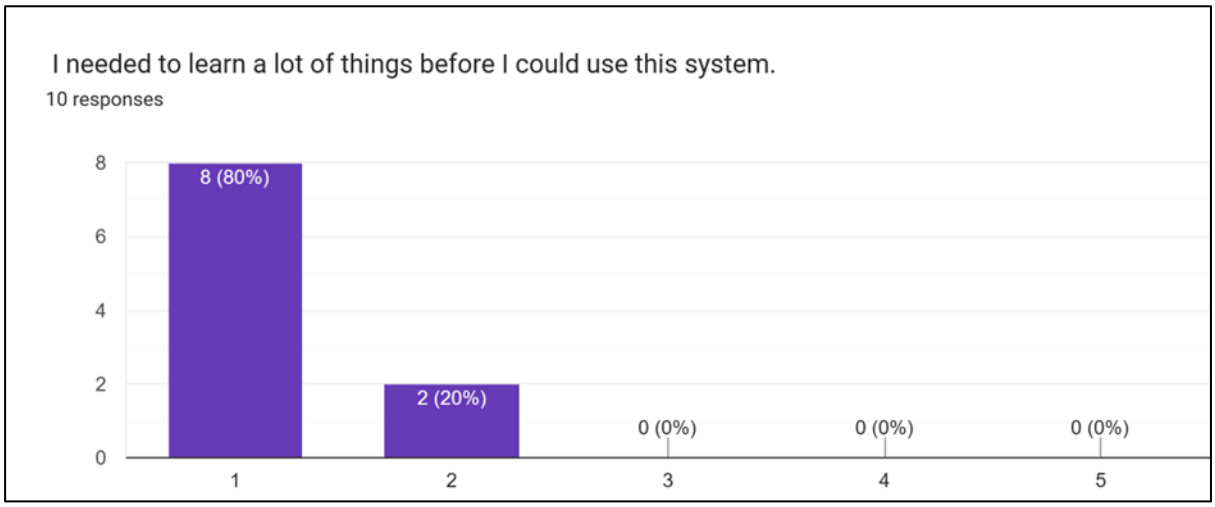

Figure 5.10 User's opinion on if they need to learn many things prior

Figure 5.10 shows strong indication that the system is beginner-friendly with low learning curve.

5.4 Conclusion

This chapter presented the evaluation of Jang through both functional and non-functional testing. Functional testing confirmed that all key features—voice input, emotion detection, response generation, and API communication—operated as expected. Non-functional testing showed that the system met performance, reliability, and usability expectations, with fast response time and stable operation. Usability testing yielded consistently high scores across all ten questions, indicating that users found Jang intuitive, easy to use, and well-integrated. Overall, the results demonstrate that Jang meets its design objectives and is perceived as a highly usable and accessible AI companion for children.

CHAPTER 6: CONCLUSION AND FUTURE WORKS

6.1 Introduction

This chapter summarises the project's accomplishments, discusses the challenges and limitations encountered, and proposes enhancements for future development. The evaluation of the system confirms that Jang has successfully met its primary objectives as an AI-powered educational and emotional support buddy for children.

6.2 Achievements

This project set out with three core objectives: to **design**, **develop**, and **evaluate** an AI-powered educational and emotional support system for children. The achievements are listed below and mapped directly to these objectives:

i. **Objective 1 - Design**: A complete system architecture was designed, including components such as the voice interface, emotion recognition logic, response engine, and backend API. The use of the Rapid Application Development (RAD) model ensured the design process was iterative and user-focused, fulfilling the objective of creating a usable and child-friendly system structure.

ii. **Objective 2 - Develop**: The system was successfully developed as a working prototype. It includes speech-to-text input, a trained machine learning model for emotion classification, natural language-based response generation, and text-to-speech output. The backend was implemented using Flask, and the system runs on a Raspberry Pi 4, achieving the objective of building a functional voice-based AI companion.

iii. **Objective 3 - Evaluate**: Results from usability testing confirmed that Jang is easy to use, intuitive, and well-integrated. Functional and non-functional testing further validated system stability and performance, fulfilling the final objective of conducting a usability-focused evaluation.

All three objectives were met, and the system demonstrates a promising foundation for future development into a fully interactive and assistive educational tool.

6.3 Limitations

Despite its success, the project has several limitations:

- **Limited emotional range**: The emotion detection model is basic and relies on a small dataset.
- **Speech recognition dependency on Internet**: The system uses Google's speech recognition API, requiring an internet connection.
- **Content depth**: Educational and storytelling content is limited to simple placeholders.

6.4 Future Work

To improve and expand Jang in future iterations:

- Expand the emotion model using a larger, more diverse dataset or a pre-trained transformer model for improved accuracy.
- Add offline speech recognition using lightweight libraries to support disconnected environments.
- Gamify educational content to make learning more engaging for children.

6.5 Conclusion

The development of Jang demonstrates the feasibility of building an AI-powered companion for children that can interact naturally, support learning, and respond empathetically. The project achieved its primary goals, particularly in terms of usability and user experience. With further development, Jang has strong potential to evolve into a robust assistive tool in educational and home settings.

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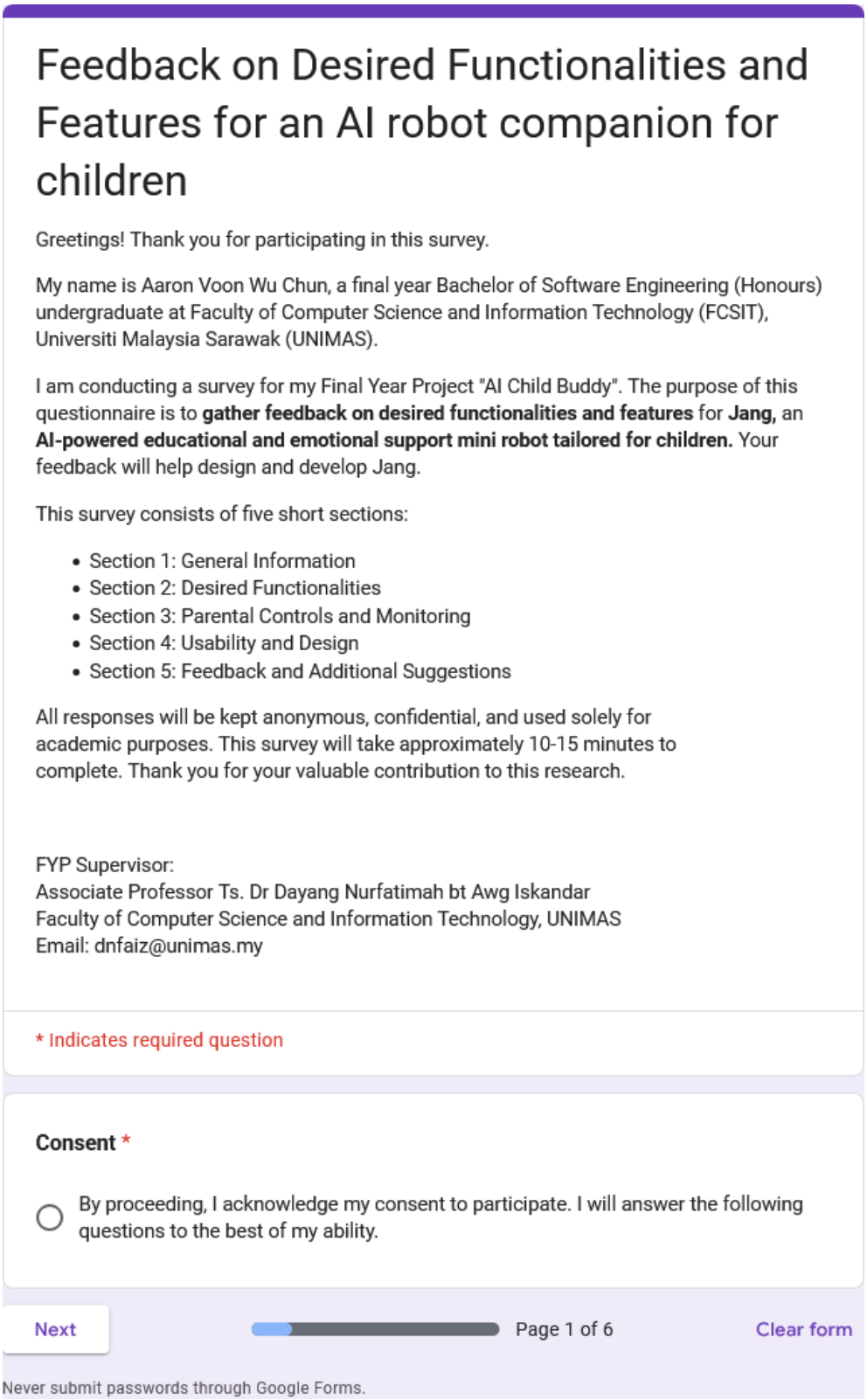
Appendices

Appendix A: Questionnaire for Feedback on Desired Functionalities and Features of Jang



Feedback on Desired Functionalities and Features for an AI robot companion for children

Greetings! Thank you for participating in this survey.

My name is Aaron Voon Wu Chun, a final year Bachelor of Software Engineering (Honours) undergraduate at Faculty of Computer Science and Information Technology (FCSIT), Universiti Malaysia Sarawak (UNIMAS).

I am conducting a survey for my Final Year Project "AI Child Buddy". The purpose of this questionnaire is to **gather feedback on desired functionalities and features** for **Jang,** an **AI-powered educational and emotional support mini robot tailored for children.** Your feedback will help design and develop Jang.

This survey consists of five short sections:

- Section 1: General Information
- Section 2: Desired Functionalities
- Section 3: Parental Controls and Monitoring
- Section 4: Usability and Design
- Section 5: Feedback and Additional Suggestions

All responses will be kept anonymous, confidential, and used solely for academic purposes. This survey will take approximately 10-15 minutes to complete. Thank you for your valuable contribution to this research.

FYP Supervisor:
Associate Professor Ts. Dr Dayang Nurfatimah bt Awg Iskandar
Faculty of Computer Science and Information Technology, UNIMAS
Email: dnfaiz@unimas.my

* Indicates required question

Consent *

By proceeding, I acknowledge my consent to participate. I will answer the following questions to the best of my ability.

Next Page 1 of 6 Clear form

Never submit passwords through Google Forms.

Appendix A (continued)

Section 1: General Information

*This section collects basic information about you and your relationship to children who may use **Jang**.*

What is your relationship to children who might use **Jang**? *

- ◯ Parent
- ◯ Educator (Teacher)
- ◯ Guardian
- ◯ Other: _____

What age group does your child/student belong to? *

- ◯ 3–5 years old
- ◯ 6–8 years old
- ◯ 9–12 years old

How familiar are you with educational or emotional support apps/tools for children? *

- ◯ Very familiar
- ◯ Somewhat familiar
- ◯ Not familiar

Appendix A (continued)

Section 2: Desired Functionalities

*This section focuses on understanding the key features and functionalities that are most important for **Jang**, such as educational content and emotional support.*

What types of educational content would you find most valuable? (Select all that apply) *

- [ ] Storytelling and reading activities
- [ ] Math problem-solving games
- [ ] Science-based interactive lessons
- [ ] Language learning (e.g., vocabulary building)
- [ ] Other: _____

How important is it for the AI to adapt to a child's progress and learning preferences? *

	1	2	3	4	5	
Not important	○	○	○	○	○	Very important

What emotional support features would you like **Jang** to have? (Select all that apply) *

- [ ] Comforting responses when the child is upset
- [ ] Motivational encouragement during learning activities
- [ ] Recognizing signs of frustration and offering help
- [ ] Other: _____

How important is the integration of interactive activities like games and quizzes to sustain engagement? *

	1	2	3	4	5	
Not important	○	○	○	○	○	Very important

What forms of interaction do you think children would prefer? *

- [ ] Voice-based conversations
- [ ] Visual displays (e.g., animations on a screen)
- [ ] Other: _____

Appendix A (continued)

Section 3: Parental Controls and Monitoring

*This section gathers insights into what parents and guardians need to monitor and manage their child's experience with **Jang**.*

Which parental control features are most important to you? (Select all that apply) *

- [ ] Content filtering to restrict certain topics
- [ ] Activity monitoring reports
- [ ] Setting time limits for usage
- [ ] Customising educational content
- [ ] Other: _____

How would you prefer to access the parental control features? *

- ( ) Mobile app
- ( ) Web-based portal
- ( ) Integrated into Jang's interface
- ( ) Other: _____

Appendix A (continued)

Section 4: Usability and Design

*This section aims to understand what design and usability features will make **Jang** engaging and easy to use for children.*

What kind of design would make **Jang** most appealing for children? *

- ◯ Bright colors and playful animations
- ◯ Simple, minimalistic design
- ◯ Themes based on popular characters or interests
- ◯ Other: _____

What usability features are most important for a child-friendly interface? *

- ☐ Easy-to-navigate menus
- ☐ Voice-based guidance for navigation
- ☐ Large buttons and icons
- ☐ Other: _____

Appendix A (continued)

Section 5: Feedback and Additional Suggestions

*This section collects your opinions on potential concerns, additional features, and overall suggestions to improve **Jang**.*

Are there any concerns you have about using **Jang**? (e.g., privacy, safety, reliability)

Your answer

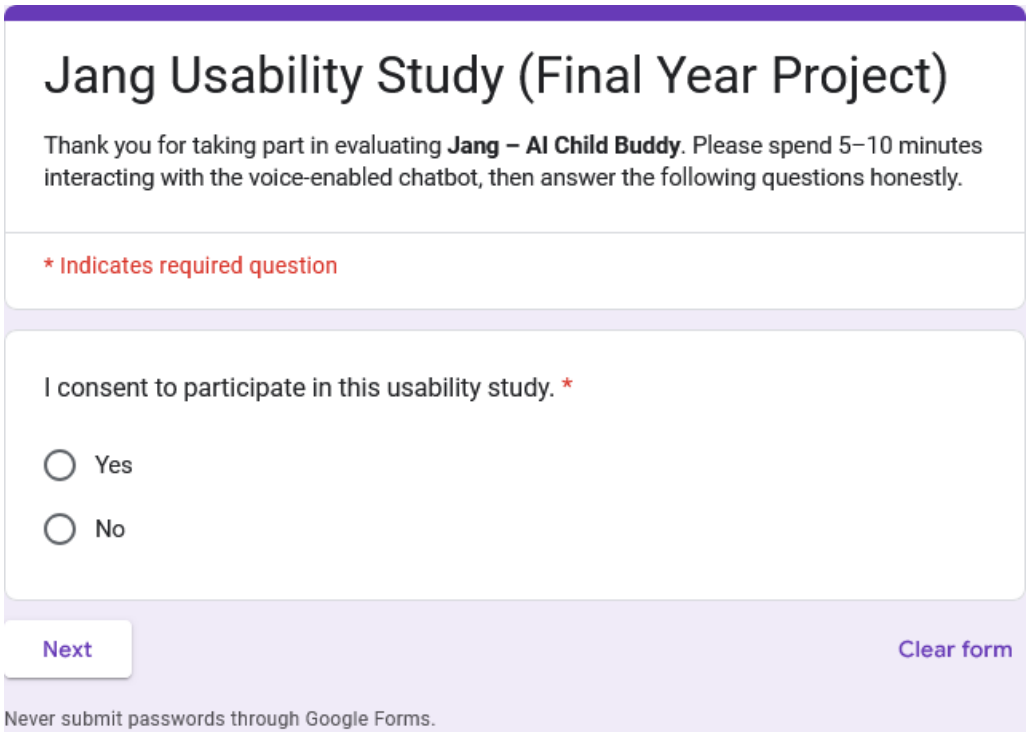
What additional features or functionalities would you like **Jang** to include?

Your answer

Do you have any other feedback or suggestions for the development of **Jang**?

Your answer

Appendix B: Questionnaire for Usability Testing



Jang Usability Study (Final Year Project)

Thank you for taking part in evaluating **Jang – AI Child Buddy**. Please spend 5–10 minutes interacting with the voice-enabled chatbot, then answer the following questions honestly.

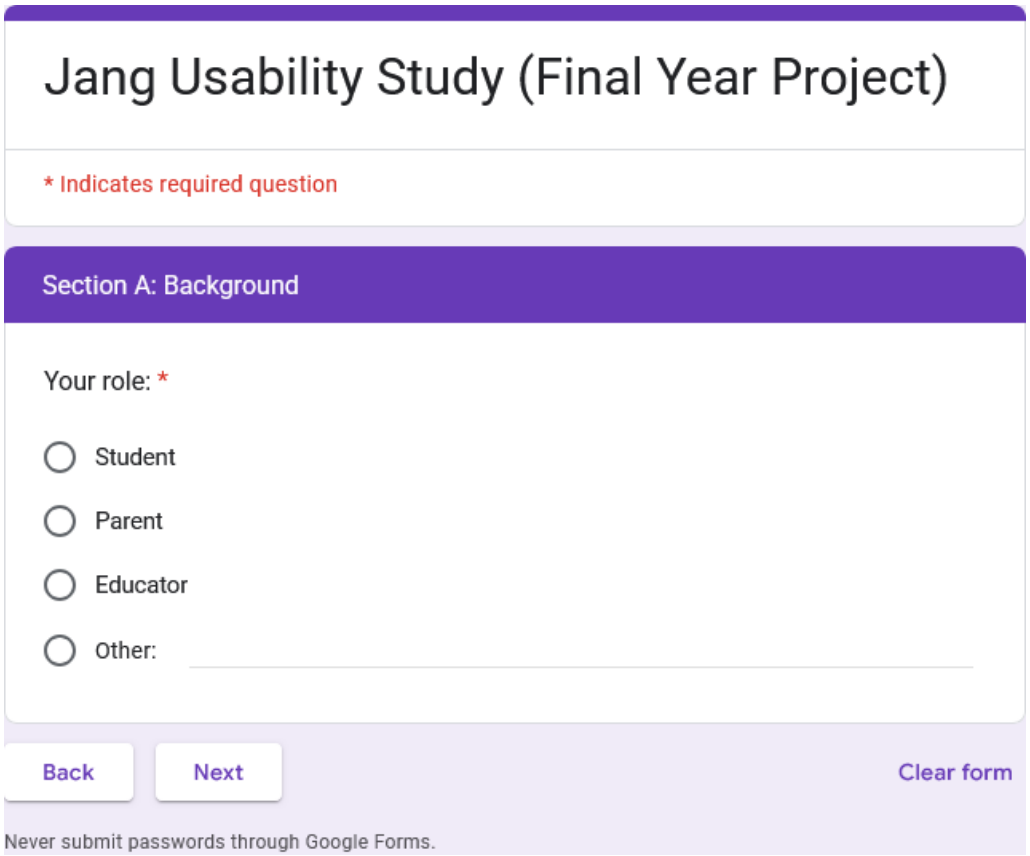
* Indicates required question

I consent to participate in this usability study. *

- Yes
- No

Next Clear form

Never submit passwords through Google Forms.



Jang Usability Study (Final Year Project)

* Indicates required question

Section A: Background

Your role: *

- Student
- Parent
- Educator
- Other:

Back Next Clear form

Never submit passwords through Google Forms.

Appendix B (continued)

Jang Usability Study (Final Year Project)

* Indicates required question

Section B: System Usability Scale (SUS)

Please rate the following statements.

I think I would like to use this system frequently. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I found the system unnecessarily complex. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I thought the system was easy to use. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

I think I would need technical support to use this system. *

	1	2	3	4	5	
Strongly Disagree	○	○	○	○	○	Strongly Agree

Appendix B (continued)