

GENERATIVE AI-POWERED INTERACTIVE CHATBOT FOR CUSTOMER
SERVICE: ASK LIBRARIAN

DISSERTATION

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requirements for the bachelor degree in the
Computer Science
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ABSTRACT OF DISSERTATION

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This dissertation explores the role of artificial intelligence (AI) in customer service, with a focus on the development and implementation of chatbots using Dialogflow, a product of Google. The definition and various applications of AI in customer service are discussed, highlighting its significance in automating processes, improving user experience, and enhancing accessibility across different industries.

The implementation of chatbots using Dialogflow is examined in detail, discussing its core components, including intents, and the differences between Dialogflow ES and Dialogflow CX. Intents, the building blocks of conversation, categorise user intentions and guide the chatbot's responses. Dialogflow ES offers a straightforward approach with intents as nodes, while Dialogflow CX provides greater flexibility with pages as nodes and state handles for controlling conversation paths.

Through a comparison of the two versions, Dialogflow CX emerges as a more advanced and scalable option, offering simplified intent management and a visual graph structure for designing conversational flows. The dissertation also delves into the practical considerations of using Dialogflow, such as training phrases and parameter extraction, to ensure accurate and effective interactions between users and chatbots.

The research methodology involves learning and utilising Dialogflow CX to develop a sophisticated chatbot, emphasising ease of use and maintenance for the client. The dissertation concludes with insights into the potential of AI-driven chatbots in

revolutionising customer service, enabling companies to operate 24/7, automate routine tasks, and provide personalised assistance to users.

Overall, this dissertation contributes to the understanding of AI in customer service and provides practical insights into the development and implementation of chatbots using Dialogflow, paving the way for future advancements in this field.

KEYWORDS: Artificial Intelligent (AI), Customer Service, Chatbot, Dialogflow.

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CHAPTER 1. INTRODUCTION

1.1 Introduction

Artificial Intelligence (AI) is a rapidly evolving field that seeks to combine computers and machines with the ability to exhibit intelligent behaviour. While the Oxford Dictionary defines AI as "the capacity of computers or other machines to exhibit or simulate intelligent behaviour," [1] this definition may oversimplify the complexity and potential of modern AI technologies.

The concept of what constitutes "intelligent behaviour" in machines is subject to ongoing debate and evolution. According to the Joint Research Centre (JRC) report, there is no standardised definition of AI due to its broad scope and constant evolution [2]. The researchers have identified common features that characterise AI systems as described in Table 1.

Table 1: Features of AI System

Features of AI Systems	Description
Perception of the environment	Involves understanding and interpreting the complexities of the real world.
Information processing	AI systems collect and interpret inputs, typically in the form of data, to derive meaningful insights.
Decision making	AI systems employ reasoning and learning techniques to make informed decisions.
Goal achievement	AI systems are designed to accomplish specific tasks or objectives.

While these features provide guidance on what constitutes an AI system, they do not offer a definitive definition. Nevertheless, they serve as a framework for understanding the essential components of AI technology.

The field of AI is characterised by rapid advancements, driven by ongoing research and technological innovation. As a result, the capabilities of AI systems continue to expand, leading to new applications and possibilities in various domains.

1.2 AI in Customer Service

AI in customer service is defined as “a technology-enabled system for evaluating real-time service scenarios using data collected from digital and/or physical sources in order to provide personalised recommendations, alternatives, and solutions to customers’ inquiries or problems, even very complex ones” by Y. Xu et al [3]. The main purpose of customer service is to provide assistance to users and customers. Therefore, for AI to be used effectively in customer service, it needs to offer help and guidance to users to solve their queries or issues. There are several examples of AI usage in customer service [4] as described in Table 2.

Table 2: Examples of AI Usage in Customer Service

AI Usage in Customer Service	Description
Customer Service Automation	Automated responses or processes that assist customers with their inquiries or tasks. Automation helps streamline repetitive tasks, allowing human agents to focus on more complex issues.

Chatbots	Programs that can interact with users in natural language, collect data, and provide tailored answers. Chatbots play a crucial role in handling customer queries efficiently, offering immediate assistance and reducing wait times.
Voice Assistants	Examples include Siri and Alexa, which use AI to understand and respond to spoken commands or queries from users. Voice assistants offer a hands-free and convenient way for customers to interact with companies and access information.
Sentiment Analysis	The ability to detect the emotions or tone in sentences. For instance, Grammarly analysis text and provides tags like formal, direct, or inspirational. Sentiment analysis helps companies understand customer feedback and adjust their approach accordingly.
Machine Learning	AI techniques such as machine learning are used to predict customer needs and analyse issues based on historical data. By analysing patterns in customer behaviour and feedback, machine learning algorithms can provide valuable insights for improving customer service processes.

1.3 Objectives

The primary objective of this dissertation is to explore the role of artificial intelligence (AI), particularly chatbots, in enhancing customer service experiences, with a specific focus on the domain of libraries. The dissertation aims to achieve the following objectives:

1. **Investigate the Impact of AI in Customer Service:** To analyse the significance of AI-driven technologies, specifically chatbots, in

revolutionising customer service practices across various industries, including libraries.

2. **Examine the Implementation of Chatbots in Libraries:** To examine the practical implementation of chatbots as virtual assistants in library settings, exploring their potential to streamline processes, improve accessibility to resources, and enhance user experiences.
3. **Explore the Functionality of Chatbots in Libraries:** To investigate the specific functionalities and capabilities of chatbots as virtual assistants in libraries, including answering inquiries, providing information on library services, offering book recommendations, and facilitating transactions.
4. **Evaluate User Satisfaction and Acceptance:** To assess user satisfaction and acceptance of chatbots in libraries, examining factors such as ease of use, usefulness, responsiveness, and overall experience from the perspective of both librarians and students.
5. **Identify Challenges and Opportunities:** To identify the challenges and opportunities associated with the adoption and integration of chatbots in library customer service, including technical limitations, ethical considerations, and potential areas for improvement.
6. **Propose Recommendations for Future Implementation:** To propose recommendations and best practices for the future implementation and enhancement of chatbots as virtual assistants in library customer service, aiming to maximise their effectiveness and impact.

By achieving these objectives, this dissertation aims to contribute to the understanding of AI-driven technologies in customer service, provide insights into the practical implementation of chatbots in library settings, and offer recommendations for optimising their functionality and usability to benefit both librarians and patrons alike.

1.4 Significant Contributions

This dissertation makes several significant contributions to the understanding and implementation of artificial intelligence (AI), specifically chatbots, in library customer service:

1. **Practical Implementation of Chatbots:** The dissertation offers practical insights into the implementation of chatbots as virtual assistants in library settings. By delving into the design, development, and deployment of chatbots using platforms like Dialogflow, it provides librarians with actionable strategies for integrating AI technologies into their customer service workflows.
2. **Functional Assessment of Chatbots:** Through a detailed examination of chatbot functionalities, including information retrieval, user assistance, and engagement, this dissertation evaluates the effectiveness of chatbots in addressing user inquiries and meeting the diverse needs of library patrons.
3. **Identification of Challenges and Opportunities:** The dissertation identifies key challenges and opportunities associated with the adoption and integration of chatbots in library customer service. By highlighting technical limitations, ethical considerations, and potential areas for improvement, it provides librarians with guidance on navigating the complexities of AI implementation.

4. **Recommendations for Future Implementation:** Based on the findings and analysis, the dissertation proposes recommendations and best practices for the future implementation and enhancement of chatbots in library customer service. These recommendations aim to assist libraries in maximising the effectiveness and impact of AI-driven technologies while addressing identified challenges.

Overall, this dissertation contributes to the advancement of library customer service practices by demonstrating the potential of AI-driven chatbots to revolutionise user experiences, streamline operations, and create more accessible and engaging library environments.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

A chatbot is a computer program designed to simulate human conversation with an end user [4][5][6]. The concept of chatbots traces back to Alan Turing's seminal question, "Can machines think?" Turing proposed a test, now known as the Turing test, where an "interrogator" communicates with a human and a machine without knowing which is which. If the machine can convincingly mimic human responses, it can be considered to "think." [7]

2.2 Related Works

2.2.1 ELIZA

The earliest example of a chatbot is ELIZA, created by Joseph Weizenbaum at MIT in 1966. ELIZA utilised a pattern-matching algorithm to respond to users based on predefined rules [8]. This laid the foundation for subsequent chatbots, which also employ pattern matching to understand user intent and provide appropriate responses. Modern chatbots, such as ChatGPT, utilise more advanced techniques like Natural Language Processing (NLP) and Deep Learning for improved performance [9].

Chatbots can be classified into three main types based on their functionality and underlying technology [10] as shown in Table 3.

Table 3: Type of Chatbots

Types of Chatbots	Description
Menu and/or button-based chatbots	The most common and user-friendly chatbots that offer pre-made options to users. While simple to use, they are limited to predefined questions and lack flexibility for complex queries.
Keyword recognition-based chatbots	Chatbots that use pattern recognition to identify keywords in user queries and provide relevant responses.
Contextual chatbots	Advanced chatbots that incorporate technologies like voice recognition to understand user emotions and intentions. They offer personalised responses based on user history and habits.

2.2.2 Chatbot market in customer service

The integration of chatbots in customer service has surged in recent years due to their ability to assist users without human intervention. According to a report by Business Insider, the chatbot market is projected to grow from USD 2.6 billion in 2019 to USD 9.4 billion by 2024, with a compound annual growth rate (CAGR) of 29.7% [9]. This growth indicates increasing investments in chatbot technology, enabling companies to operate 24/7 by automating routine tasks and allowing staff to focus on more complex issues.

Market future research [12] forecast that chatbots Market was valued at USD 2.47 Billion in 2021 and is projected to reach USD 24.64 Billion by 2030, with a compound annual growth rate (CAGR) of 23.91% during the forecast period (2024 - 2030) as shown in Figure 1. Chatbots are conversational agents designed to interact with humans through communication channels, primarily accessed via the internet. Leveraging artificial

intelligence, these chatbots can perform various tasks and are widely utilised across industries for their versatility and applications.

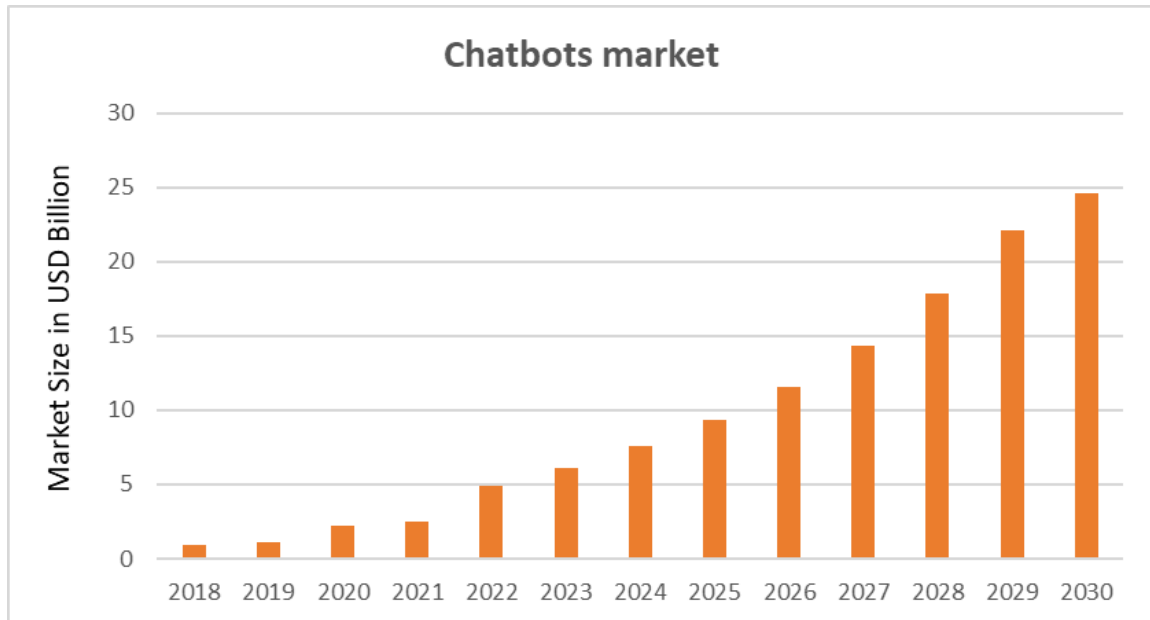


Figure 1: Chatbots Market Size, 2022-2030 (USD Billion)¹

The Chatbots Industry has experienced significant growth over the past decade, largely driven by the widespread adoption of artificial intelligence and the increasing reliance on online messaging. This technology is favoured for its ability to streamline communication and automate tasks, leading to improved efficiency and customer service across various sectors. With the proliferation of digital platforms and the growing demand for seamless user experiences, the chatbots market is expected to continue expanding rapidly in the coming years.

The significance of chatbots extends beyond customer service. They are increasingly used in various industries such as healthcare, finance, and education to streamline processes, improve accessibility, and enhance user experience. For instance, in

¹ Secondary Research, Primary Research, MRFR Database, and Analyst Review

healthcare, chatbots assist patients with scheduling appointments, providing medical advice, and monitoring health metrics. In finance, they facilitate transactions, offer personalised financial advice, and provide customer support. In education, chatbots help students with course enrollment, assignment assistance, and educational resources.

Despite the advancements in chatbot technology, challenges remain, particularly in areas such as natural language understanding, context awareness, and ethical considerations. Ensuring that chatbots effectively understand and respond to diverse user queries while maintaining user privacy and security is an ongoing endeavour.

2.2.3 Dialogflow Framework for chatbot development

Dialogflow, a product of Google, is an Application Programming Interface (API) available to the public, enabling developers to create sophisticated chatbots with ease [13]. It offers a user-friendly interface and requires minimal effort from developers to build a functional chatbot. The core component used by Dialogflow to understand user needs in a conversation is intents, as mentioned in the "Definition of Chatbot" section. Intents are essentially the building blocks of conversation, representing the user's intentions or goals.

Dialogflow simplifies the process of creating chatbots by providing a straightforward user interface and requiring developers to input multiple sentences and keywords as training data for each intent they want the chatbot to recognize. Once trained, the chatbot can identify intents in user conversations and respond appropriately, either with static replies or more complex responses if additional features are integrated.

Dialogflow is available in two versions: Dialogflow ES and Dialogflow CX [14]. Each version has its own advantages and uses, employing different formats and approaches to building conversational interfaces.

Before delving into the differences between Dialogflow ES and Dialogflow CX, it's essential to understand some key concepts. The primary concept is intents, which categorise the user's intentions in a conversation [15]. Intents are constructed with training phrases provided by developers, representing example conversations users might have on a particular topic. For instance, if an intent is created to identify positive or confirmation intentions, training phrases could include "Sure!", "Yes, please," and "Yeah." Developers can also annotate training phrases to extract specific parts of a conversation as parameters. For example, in the phrase "Tomorrow I want the parcel to be sent to London," "tomorrow" and "London" can be annotated with the "date" and "location" parameters, respectively. Dialogflow then extracts these parameters from user replies matched with the intent, eliminating the need to create additional parameters.

Dialogflow ES, the first version of Dialogflow, consists of intents as nodes and uses contexts to control conversation paths [16]. This results in a linear conversation path that attempts to simulate a non-linear conversation by connecting various nodes with contexts. Since each intent is created with various fulfilments, conditions, and responses for a specific purpose, they are typically not reused. This can lead to the creation of numerous intents if developers intend to invoke another intent from the user further into the conversation. Dialogflow ES is suitable for simple to moderately complex chatbots, such as Frequently Asked Questions (FAQ) chatbots or for extracting information from users [16].

On the other hand, Dialogflow CX is a more advanced version than Dialogflow ES, offering greater flexibility and scalability. In Dialogflow CX, conversation paths are created using pages as nodes and state handles as conditions to control paths [16]. Intents are simplified, removing the need to combine them with fulfilments and conditions, making them more reusable and modular. Another key difference is the User Interface (UI), which displays the conversational structure as a graph in Dialogflow CX, allowing developers to plan and observe the overall structure of the chatbot more effectively.

In conclusion, Dialogflow is a powerful tool for building conversational interfaces, allowing developers to create sophisticated chatbots with ease. Understanding the differences between Dialogflow ES and Dialogflow CX is essential for choosing the appropriate version based on the complexity and requirements of the chatbot project.

2.3 Conclusion

In conclusion, chatbots represent a significant advancement in AI technology, offering solutions to various challenges in human-computer interaction. Their versatility, scalability, and potential for automation make them valuable tools across different domains, with continued growth expected in the coming years.

CHAPTER 3. METHODOLOGY

3.1 Introduction

Initially, a chatbot was considered using Python, Natural Language Toolkit (NLTK), and TensorFlow. However, it was realised that using these tools would result in a simple and primitive chatbot compared to others in the market. With numerous basic chatbots already available, a more modern approach was sought.

Dialogflow CX from Google, a new and emerging technology, was chosen to create a more advanced and user-friendly chatbot. The goal shifted towards using Dialogflow CX to develop a chatbot that is easier to use and maintain for the client. After creating a simple chatbot last year, the focus shifted fully to learning and utilising Dialogflow CX.

The chatbot development process involved combining Dialogflow CX as the main chatbot system with Google Cloud Functions for database management, webhooks, and data storage. These technologies were used to train the chatbot on a diverse set of training data to improve its performance and responsiveness.

In the following sections, the technologies used and learned over the past few months to develop this chatbot will be discussed in detail, along with their implementation and impact on the final product.

3.2 Building a Chatbot using Dialogflow

The section outlines the steps involved in building a chatbot using Dialogflow, a conversational AI platform developed by Google. This methodology provides a structured approach to designing, implementing, testing, deploying, and maintaining a

chatbot for various use cases, such as customer support, information retrieval, and transactional interactions. The design and implement of the chatbot agent is based on Google documentation [15][16][17][18]

3.2.1 Define Objectives and Use Cases

In this initial phase, the objectives and use cases of the chatbot are defined. Objectives may include providing customer support, answering frequently asked questions (FAQs), or facilitating notification. For this final year project, the use cases for the chatbot are to help librarians to manage a book inquiry, FAQs and help desk for the library.

3.2.2 Chatbot System Architecture

Figure 2 illustrates the architecture of the librarian chatbot system. In this architecture:

- The end-user interacts with the chatbot through various channels such as messaging platforms or websites.
- Dialogflow processes the user input and matches it to the appropriate intent.
- If additional action is needed, Dialogflow sends a request to the webhook service.
- The webhook service performs the necessary actions, such as sending emails or accessing external databases.
- The chatbot responds to the user based on the webhook service's instructions.

- This architecture ensures efficient handling of user queries and seamless integration with external services to provide a smooth user experience.

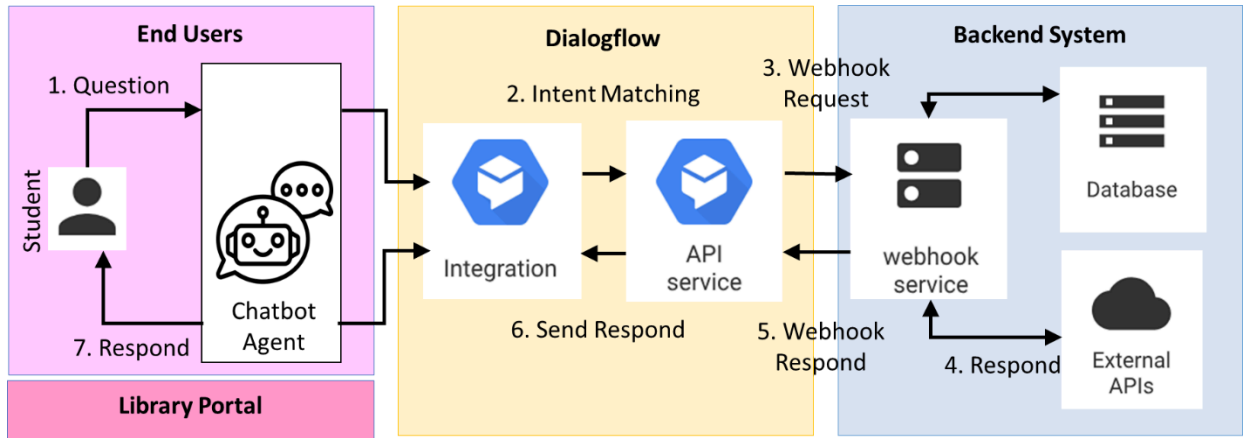


Figure 2: Library Customer Service Chabot System Architecture

A Dialogflow agent serves as a virtual agent that manages concurrent conversations with end-users. It acts as a natural language understanding module, translating end-user text into structured data that can be understood by applications and services. The agent is designed and built using Dialogflow Workbench to handle various types of conversations required for the system.

An intent categorises an end-user's intention for one conversation turn. For each agent, multiple intents are defined to handle different aspects of the conversation. When an end-user communicates with the chatbot, Dialogflow matches their input to the best intent defined in the agent. This process, known as intent classification, determines how the chatbot responds.

For example, let's consider a chatbot designed to handle inquiries about library books. Within the chatbot, an intent can be created specifically to address questions about book availability. If a student asks, "Is the book 'Algebra for dummies' available?",

Dialogflow matches this input to the intent designed for handling such queries. The chatbot then responds accordingly, providing information about the availability of the book or terminating the conversation if necessary. This process flow ensures that users receive prompt and accurate responses to their queries, enhancing their overall experience with the chatbot and improving the efficiency of library services. If further action is required based on the matched intent, Dialogflow can send a request to a webhook service along with information about the intent. The webhook service can then perform any necessary actions and provide instructions on how to proceed. For example, in the case of the library chatbot uses the webhook service to fetch data from the database and send the answer to the student regarding the availability of the requested book.

3.2.3 Design Conversational Flow

The design phase involves mapping out the conversational flow of the chatbot. This includes defining user intents, entities, and responses. Intents represent the different types of user interactions the chatbot will recognize, while entities are parameters extracted from user inputs. Clear and concise responses are designed for each intent to ensure an effective user experience.

In the conversational flow, there are two main concepts that must be understood, pages and flows. Pages act as a node for a particular task or event. As an example, a page named “Collect book ID” will call the webhook service to collect the book ID from the server and return the value as a parameter into the chatbot. Flows act as sectors for different sections or topics to contain the multiple pages associated with the flow. As an

example, the “Collect book ID” page is created in the “Library Book” flow as the page is associated with the collection of library books id codes.

In the current version of the chatbot, three distinct flows have been created: “Library Books,” “Library FAQ,” and “Library Help Desk.” These flows are designed to demonstrate the various options available in Dialogflow for addressing user queries, each with its own unique approach tailored for efficiency and suitability. To access these flows, the user's input must match one of the intents created, redirecting the user to the specified flow accordingly. The next subsequent subsection describes each flow in detail, outlining their specific functionalities and how they contribute to the overall operation of the chatbot system.

3.2.3.1 Library Books Flow

The “Library Books” flow is designed to assist users in finding information about books available in the library. The main concept implemented in this flow is the usage of the “Spanner” database and “Unstructured documents” data stores to respond to user inquiries about library books.

The “Unstructured documents” data store contains formatted text files created to train the chatbot with relevant information about the books in the library. Each document represents a specific book and includes details such as the title, author, genre, and availability status. When a user queries the chatbot about a particular book, the system searches the “Unstructured documents” data store for relevant information and retrieves the most appropriate response.

Additionally, the “Spanner” database is utilised to check the availability of the book in real-time. By querying the database, the chatbot can determine whether the requested book is currently available for loan or if it is checked out.

The integration of the “Spanner” database and “Unstructured documents” data store ensures that users receive timely and relevant responses to their book-related queries. The chatbot is equipped to provide information about the availability, location, and other details of library books, enhancing the user experience and streamlining the process of accessing library resources.

3.2.3.2 Library FAQ Flow

The “Library FAQ” flow is dedicated to addressing frequently asked questions from users regarding library services, policies, and procedures. This flow demonstrates the usage of the “FAQ” data store, which utilises a comma-separated value (CSV) file to train the chatbot with predefined questions and answers.

The “FAQ” data store contains a comprehensive list of common questions and their corresponding answers, covering a wide range of topics relevant to library users. These questions may include inquiries about library hours, borrowing policies, fines, services offered, and more.

When a user poses a question to the chatbot, it searches the “FAQ” data store for the most accurate match and retrieves the corresponding answer. The chatbot then provides the user with the relevant information, helping to resolve their query quickly and efficiently.

By leveraging the “FAQ” data store, the chatbot streamlines the user experience by providing instant access to information without the need for manual intervention. Users can obtain answers to their questions at any time, reducing the reliance on library staff and improving overall satisfaction.

3.2.3.3 Library Help Desk Flow

The “Library Help Desk” flow is designed to address more complex user queries or issues that may require guided assistance and troubleshooting. This flow demonstrates the versatility of Dialogflow in handling multi-step interactions and providing personalised support to users.

In the “Library Help Desk” flow, users are guided through a series of conversational pages, each designed to gather specific information or address a particular issue. These pages are interconnected, allowing the chatbot to navigate through the conversation flow based on the user's responses.

This approach is particularly useful for handling queries that cannot be resolved through simple responses or require additional context from the user. For example, if a user reports a problem with accessing an online resource, the chatbot can guide them through a series of troubleshooting steps to diagnose the issue and provide a solution.

By utilising a conversational flow, the chatbot can effectively collect information, troubleshoot problems, and provide tailored assistance to users, enhancing the overall user experience and ensuring that their needs are addressed comprehensively.

In summary, the implementation of these three flows showcases the capabilities of Dialogflow in providing efficient and effective solutions to user queries in a library

setting. By leveraging various features and functionalities offered by Dialogflow, developers can create chatbots that streamline library operations, enhance user engagement, and improve overall satisfaction. The “Library Books” flow demonstrates how users can easily access information about available library resources, while the “Library FAQ” flow provides instant answers to common questions, reducing the need for manual intervention. The “Library Help Desk” flow offers personalised support for more complex issues, guiding users through troubleshooting steps and providing tailored assistance.

Overall, these flows contribute to a more seamless and user-friendly library experience, empowering users to find information, resolve issues, and access library resources with ease. As technology continues to advance, chatbots will play an increasingly vital role in providing efficient and personalised customer service in library settings and beyond.

3.2.4 Setup Dialog Flow Project

A new project is created in Dialogflow, and the settings are configured according to the defined objectives and use cases. This includes setting the agent's default language, enabling integrations with messaging platforms, and configuring webhooks for backend processing if necessary. Figure 3 shows a Dialogflow workbench to build the chatbot agent that will be attached to the end user application.

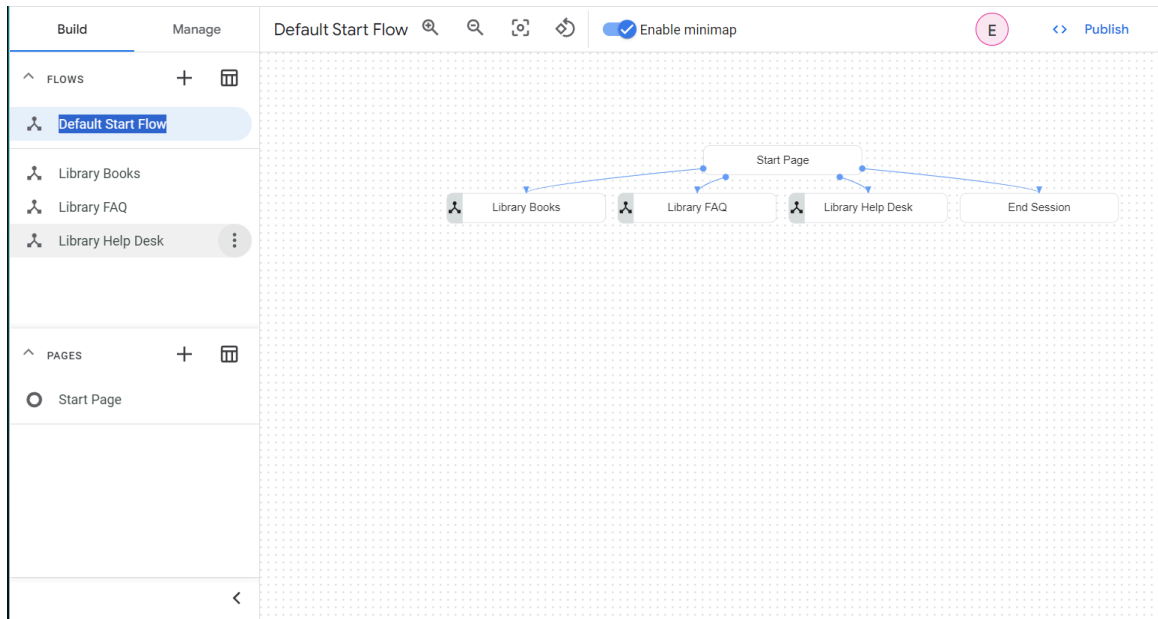


Figure 3: Dialogflow Workbench

The design and development of the chatbot involve creating separate flows for Library Books, Library FAQ, and Library Help Desk, each utilising different features available in Dialogflow. To effectively manage and create the chatbot, four key sections are utilised: the "Build/Manage" tab, the "flows section," "pages section," and the "overview section."

In the "Build/Manage" tab, developers can access and organise various elements of the chatbot, including its intents, entities, and fulfilment settings. The "flows section" allows developers to create and manage different conversation flows, while the "pages section" enables the creation and management of individual pages within those flows.

Figure 4 illustrates a Library Book flow, showing all the flows and pages within their respective flow sections. In the overview section, coloured arrows depict the conversational flow of the chatbot, showing how pages transition into one another, move to another flow, or end the session. This structured approach to designing the chatbot

ensures that each flow is tailored to address specific user queries effectively and efficiently, enhancing the overall user experience.

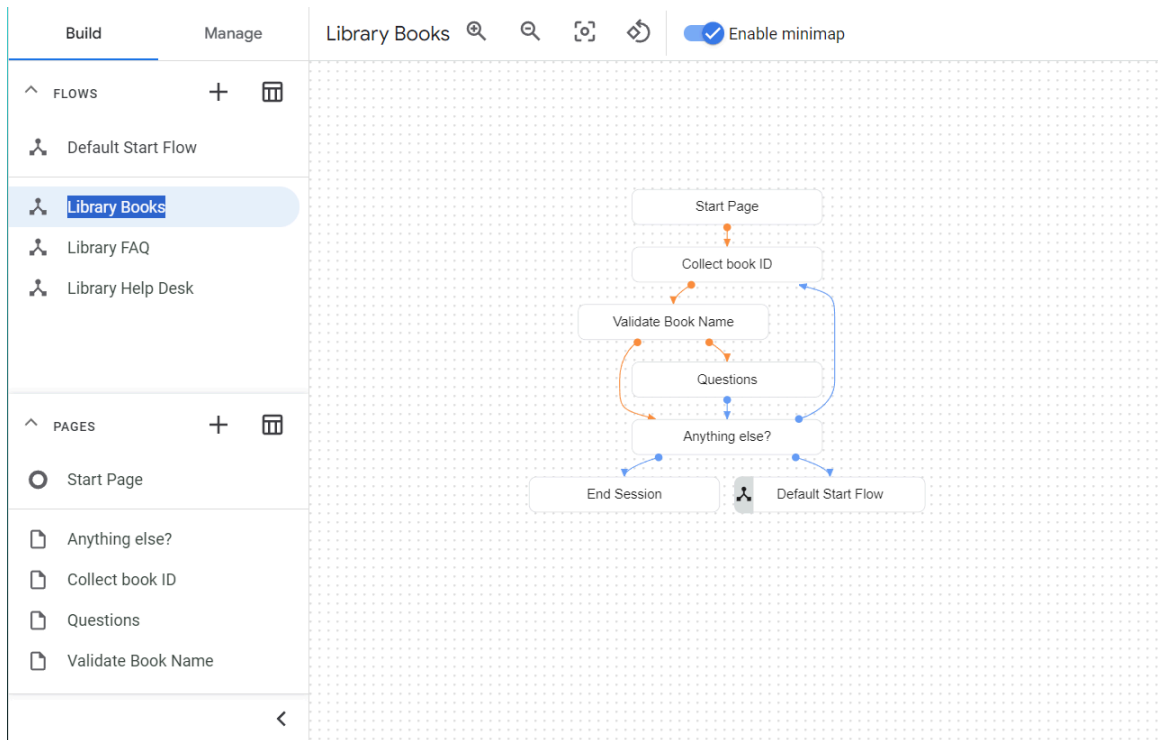


Figure 4 Dialogflow for the “Library Books” flow

In the Library Books flow, a student begins by asking if a particular book is available using its bookID. This bookID is then searched for in the cloud storage bucket [19], which acts as the container for the chatbot's data. Buckets a storage in Google Cloud that manages data and controlled access to information, ensuring that the chatbot can efficiently retrieve and deliver the requested information to users.

Once located, Dialogflow retrieves the relevant information from the associated document. For example, the student may inquire about the author, title, or description of the book. Dialogflow processes these queries and provides accurate responses based on the information stored in the document.

If there are no further questions, the chat session ends. This systematic process enables students to easily access detailed information about library books, making the chatbot an efficient and user-friendly tool for navigating library resources.

Figure 5 illustrates a Library FAQs flow, showing all the flows and pages within their respective flow sections.

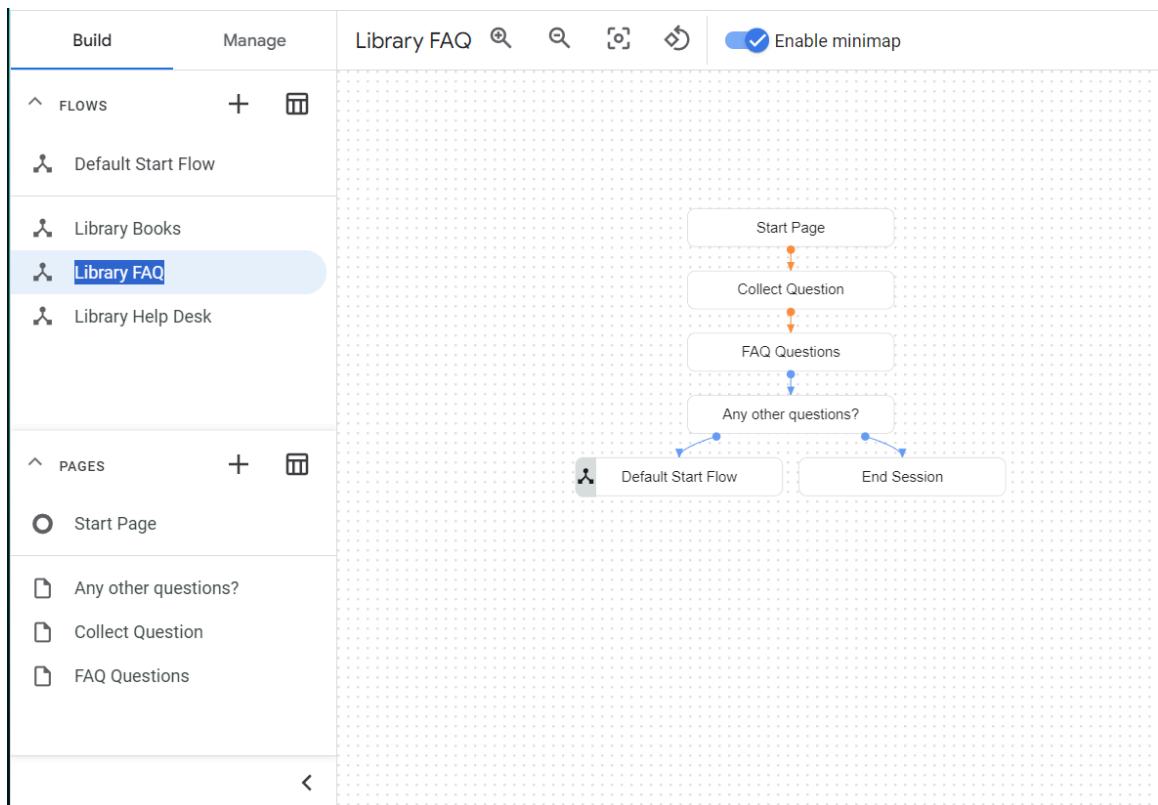


Figure 5: Dialogflow for the “Library FAQ” flow

In the Library FAQ flow, students can ask frequently asked questions (FAQs) about the library. This flow shows the use of the “FAQ” data store, which employs a comma-separated value (CSV) file to train the chatbot with predefined questions and answers. The “FAQ” data store contains an extensive list of common questions and their

corresponding answers, covering various topics relevant to library users, such as library hours, borrowing policies, fines, and services offered.

When a user poses a question to the chatbot, it searches the “FAQ” data store for the most accurate match and retrieves the corresponding answer. The chatbot then provides the user with the relevant information, assisting in resolving their query quickly and efficiently. This user-friendly approach enables students to obtain answers to common questions about the library without the need for human intervention, enhancing their overall experience with library services.

Figure 6 illustrates the Library Help Desk flow, showcasing all the flows and pages within their respective sections. This approach is particularly valuable for addressing queries that cannot be resolved through simple responses such as Library FAQs or require additional context from users, such as students to guide through the conversation.

For example, in this flow, if a student reports a problem with accessing an online resource, the chatbot can guide them through a series of troubleshooting steps to diagnose the issue and provide a solution, such as resolving a password issue.

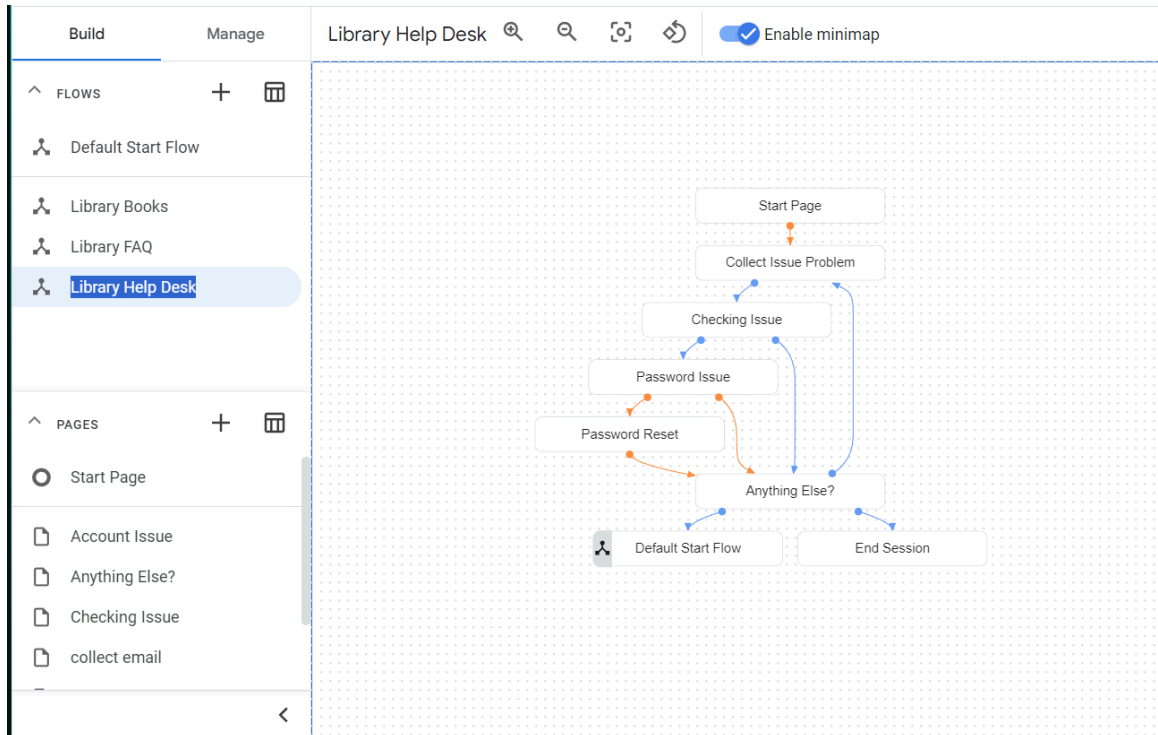


Figure 6: Dialogflow for the “Library Help Desk” flow

By employing a conversational flow, the chatbot can effectively gather information, troubleshoot problems, and offer tailored assistance to users. This enhances the overall user experience and ensures that users' needs are comprehensively addressed. The interactive nature of the chatbot allows for a more dynamic and engaging interaction, enabling users to resolve issues more efficiently and with greater satisfaction. Moreover, the Help Desk flow provides a structured approach to problem-solving, guiding users through a series of steps to identify and resolve their issues effectively.

3.2.5 Create Intents and Entities

Intents and entities form the core components of the conversational flow within Dialogflow, allowing the chatbot to understand and respond to user queries effectively.

Intents represent the user's intention or goal in a conversation, while entities extract specific information from user inputs to provide more relevant responses.

In the design process, training phrases are added to each intent to teach the chatbot how to recognize user queries. These phrases encompass various ways users might express the same intent, ensuring the chatbot's accuracy in understanding user input. Figure 7 illustrates an example of an intent with its associated training phrases. In this case, the intent is designed to detect any FAQ inquiries from the user, with phrases such as "faq" and "library questions."

Multiple intents are typically required to create a comprehensive chatbot. Among these, confirmation and negative intents are essential, as many queries can be resolved with simple "yes" or "no" responses. Figure 8 provides a glimpse of the total intents used in the chatbot's creation.

Entities play a crucial role in classifying specific words or phrases as synonyms for an entity. For example, in Figure 9, the entity "big" includes synonyms such as "humongous" and "huge." This ensures that variations of words are understood and interpreted consistently by the chatbot. Entities are particularly useful for handling words with multiple variations, such as colours and sizes.

Build	Manage	← Intent Save Cancel	E	Publish Agent settings Test Agent
RESOURCES		⏸ Skip auto annotation ⓘ	⬆ ⬇	
Intents		🔍 Search Search training phrases		
Entity types		<input type="checkbox"/> Training phrases	# words	
Webhooks		<input type="checkbox"/> some library questions	3	🗑
Route groups		<input type="checkbox"/> some questions about the library	5	🗑
Data stores [new]		<input type="checkbox"/> I have some questions	4	🗑
Generators		<input type="checkbox"/> faq	1	🗑
TEST & FEEDBACK		<input type="checkbox"/> faq please	2	🗑
Test cases		<input type="checkbox"/> FAQ help	2	🗑
Validations		<input type="checkbox"/> i need help with FAQ	5	🗑
Change history		<input type="checkbox"/> FAQ please	2	🗑
Conversation history		<input type="checkbox"/> FAQ	1	🗑
Analytics [new]		<input type="checkbox"/> questions	1	🗑
TESTING & DEPLOYMENT				
Git				
Versions				

Figure 7: Dialogflow “Library FAQ” intents

Additionally, Dialogflow offers system entities, which are predefined entities within the system. These entities are designed to extract specific formats of information from user inputs. For instance, the "`@sys.email`" entity extracts only the email address from a user's reply. System entities are often paired with parameters to extract relevant information from user inputs. Figure 10 provides an example of how system entities are utilised in conjunction with parameters.

Overall, the effective use of intents and entities allows the chatbot to understand user queries accurately and provide relevant responses. By incorporating various training phrases and defining entities appropriately, the chatbot can handle a wide range of user inputs and enhance the overall conversational experience.

Build	Manage	Intents	+ Create	Import	E	<> Publish	Agent settings	Test Agent
RESOURCES								
Intents								
Entity types								
Webhooks								
Route groups								
Data stores [new]								
Generators								
TEST & FEEDBACK								
Test cases								
Validations								
Change history								
Conversation history								
Analytics [new]								
TESTING & DEPLOYMENT								
Git								

Q Search	Search intents by ID, display name, or label		
Display name	Labels	# of Training phrases	Last modified
<input type="checkbox"/> Default Welcome Intent		17	Apr 27, 2024 11:13 AM
<input type="checkbox"/> Default Negative Intent		0	Apr 27, 2024 11:13 AM
<input type="checkbox"/> user.refind.book		13	Apr 30, 2024 06:33 PM
<input type="checkbox"/> user_negative		19	Apr 29, 2024 12:27 PM
<input type="checkbox"/> help_login		22	May 1, 2024 11:09 PM
<input type="checkbox"/> library_book		22	May 2, 2024 10:57 PM
<input type="checkbox"/> user.done		11	Apr 30, 2024 12:33 PM
<input type="checkbox"/> library_troubleshoot		19	Apr 29, 2024 12:44 PM
<input type="checkbox"/> library_faq		13	Apr 29, 2024 12:58 PM
<input type="checkbox"/> user.restart		13	Apr 30, 2024 06:37 PM

Items per page: 10 1 - 10 of 13

Figure 8: Dialogflow list of intents

Entity type

Save

Cancel

Import to Entity

E

<> Publish

Agent settings

Display name *

Size

Can contain letters, numbers, underscores and dashes. Must start with a letter.

Entities only (no synonyms)

Regexp entities

Entities

To add an entity, enter a reference value and optional synonyms. For example, if *vegetables* is the entity type, you might have *scallion* as a reference value and *green onion* as an optional synonym.

Q Search

Search entities

Entity	Synonyms	
Big	Big × humongous × large ×	🗑️ 📄
Medium	average × M × Medium ×	🗑️ 📄
small	S × small × tiny ×	Add

Figure 9: Creating a custom entity

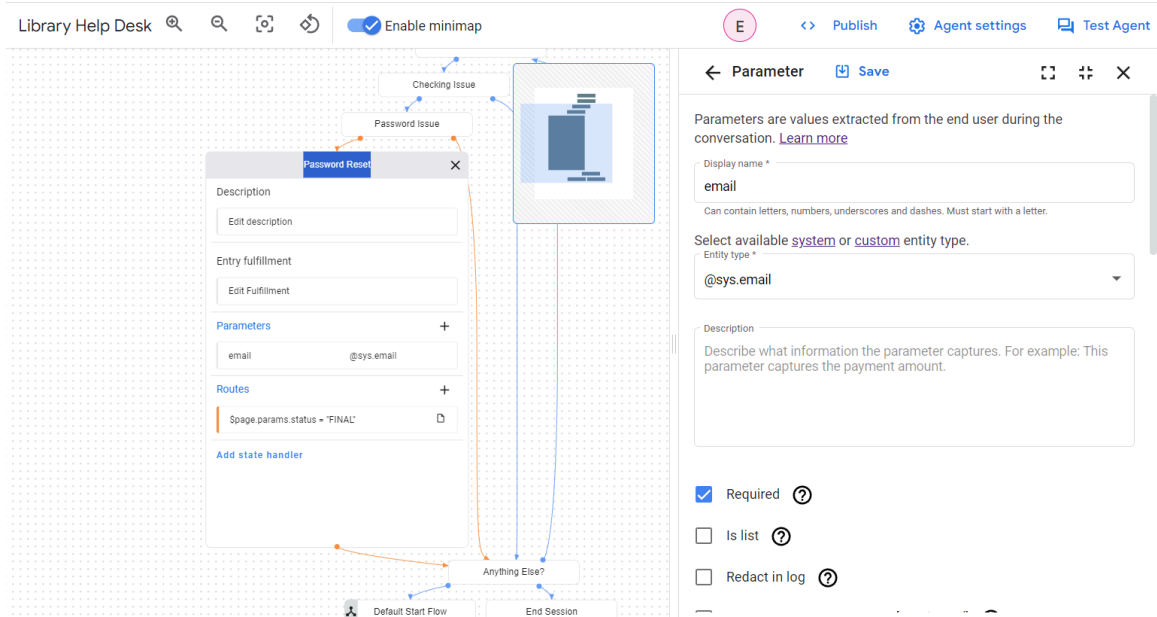


Figure 10: Chatbot system entity

3.2.6 Parameters

Parameters serve as variables to collect user information or store data in Dialogflow. There are two primary methods for gathering or storing parameters within the platform.

Firstly, the chatbot can prompt users for specific information, such as a telephone number or email address, as shown in Figure 11. This method involves configuring the parameter name and entity type in the parameter section of Dialogflow. By asking targeted questions, the chatbot can efficiently collect the necessary data from users.

Secondly, annotations are utilised to extract specific parts of user input as parameters. These annotations are configured within the intents section when creating intents. Similar to implementing entities, annotations enable the chatbot to identify and extract relevant information from user queries, enhancing its ability to understand and respond accurately.

Both methods enable the chatbot to gather essential information from users, facilitating personalised interactions and improving the overall user experience. By effectively managing parameters, the chatbot can provide more tailored responses and fulfil user needs more effectively

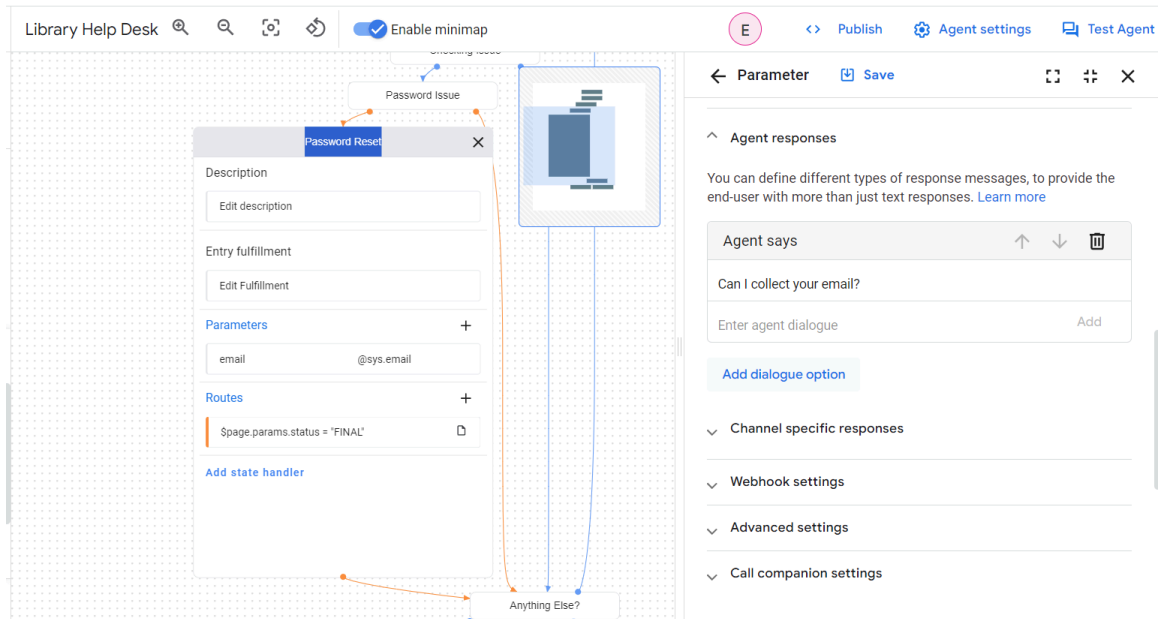


Figure 11: Parameter inquiry

3.2.7 Routes

Routes are crucial for facilitating the flow of conversation within a chatbot, enabling pages to transition to one another seamlessly. Each page in a chatbot must have a route to ensure the chatbot's functionality. At the end of the conversation flow, the final page typically transitions to the "End Session" page, effectively concluding the interaction with the user.

Routes are triggered by either intents or conditions configured within the page. For example, in Figure 9, there is a transition from the "Start Page" to the "Library Books" flow when the "library_book" intent is triggered. Similarly, Figure 10 demonstrates a transition based on conditions rather than intents. In this case, the transition occurs if the parameter "book_availability" is true.

Furthermore, routes provide the option to add parameters using the parameter presets feature. This feature allows the addition of single or multiple parameters without the need to trigger a specific intent or request user input. This is particularly useful for conditional routes that rely on certain parameters in subsequent pages. Additionally, it is beneficial for yes or no questions where parameters can be added automatically based on user responses, as depicted in Figure 12.

Overall, routes play a vital role in orchestrating the conversational flow of the chatbot, ensuring smooth navigation and effective interaction with users.

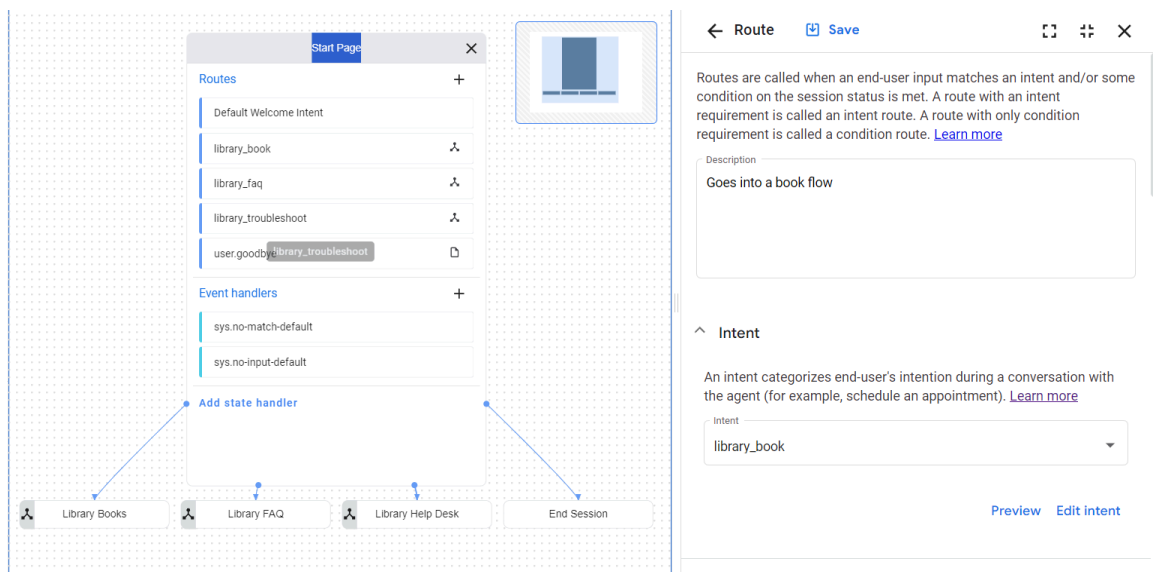


Figure 12: Route triggered by Intent

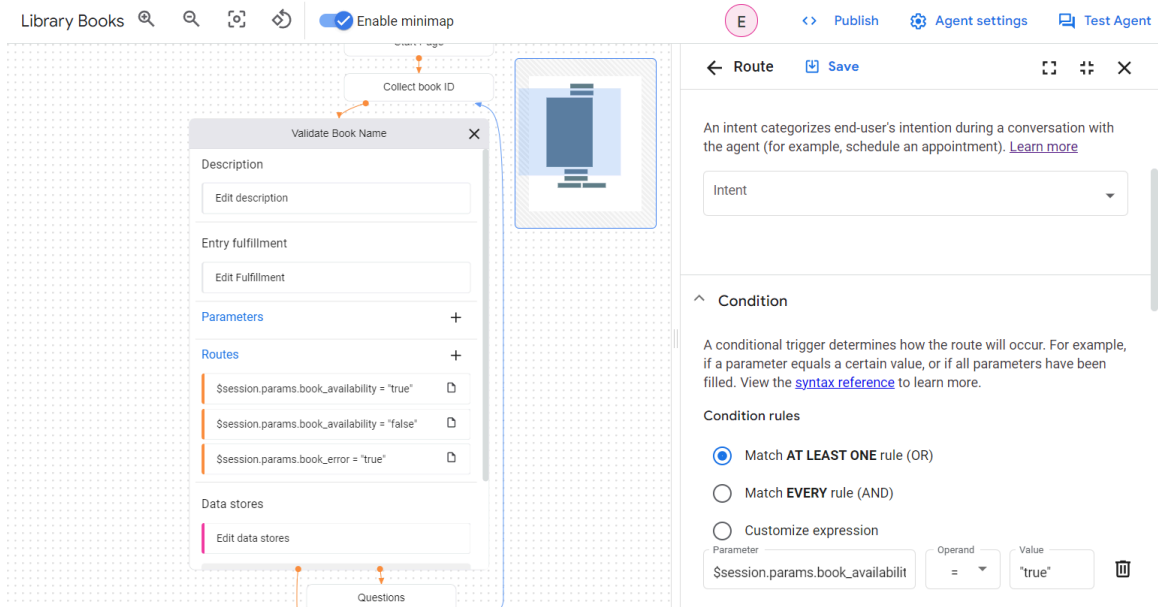


Figure 13: Route triggered by conditions

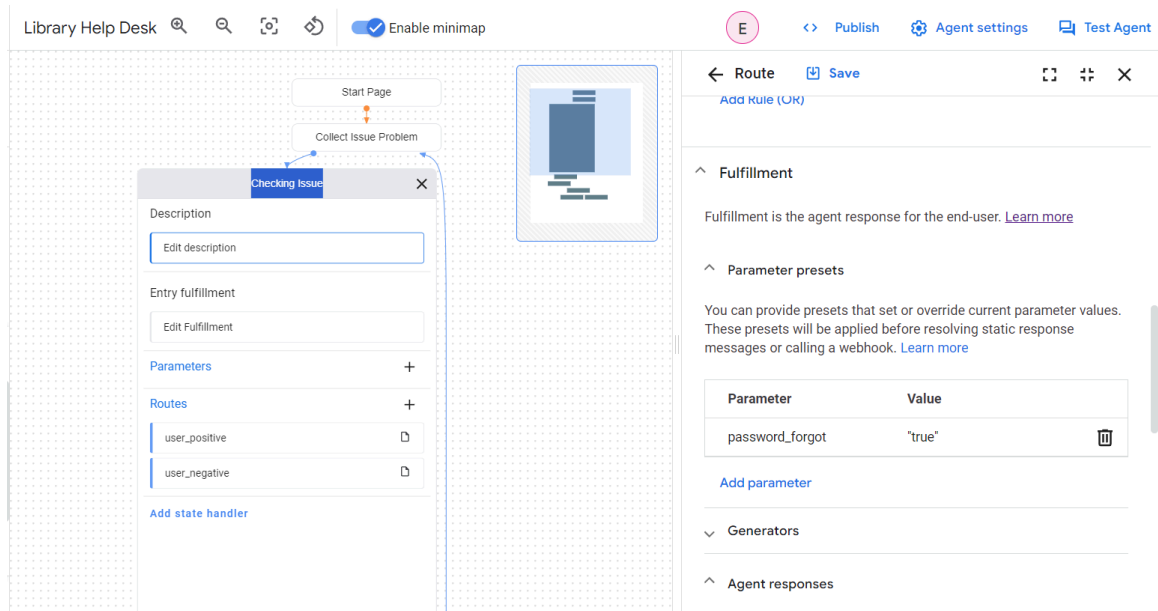


Figure 14: Parameter Presets

3.2.8 Implement Fulfilment

If the chatbot requires backend processing or integration with external systems, fulfilment is implemented using webhook integration. Webhook services are developed to

handle user requests, process data, and provide dynamic responses back to the chatbot. Extending the webhook services, there are also the creation and usage of the database and data store to enrich the user service provided by the chatbot. Both the database and data store are accessed through the webhook.

The webhook is initialised with the creation of the database client and defines all the types and variables that will be used. Then, each function is created and named based on the tags that were given in the Dialogflow interface. For example, in Figure 15, a test function is created to test if the webhook is working properly in Dialogflow. When the webhook tag "test" is triggered in Dialogflow, the same named tag in the webhook will be executed.

```
67
68 func test (ctx context.Context, request webhookRequest) (webhookResponse, error) {
69     p := map[string]interface{}{
70         "test_success": "success",
71     }
72     // Build and return the response.
73     response := webhookResponse{
74         SessionInfo: sessionInfo{
75             Parameters: p,
76         },
77     }
78     return response, nil
79 }
80
```

Figure 15: Test Function

The function creates a new parameter called "test_success" with the value "success," which is then added into the response variable as a parameter due to the structure of the variable. The response is then sent to Dialogflow as a parameter value.

Figure 16 shows the snippet of code that calls the database and extracts a value from the database. Line 87 requests the parameter "bookid" from the session in Dialogflow to be used as the primary key to find the correct row in the database. Line 95 then requests the "bookAvailability" column in the database, allowing the webhook to

check the value of the "bookAvailability" and return a boolean value as a parameter to be used in Dialogflow.

```
83 // bookIDChecker handles same-named tag.
84 func bookIDChecker(ctx context.Context, request webhookRequest) (
85     webhookResponse, error) {
86     // Get the existing parameter values
87     IDbook := request.SessionInfo.Parameters["bookid"].(float64)
88     intIDbook := int64(IDbook)
89     available := "false"
90     if client != nil {
91         // Accessing the spanner database
92         row, err := client.Single().ReadRow(ctx,
93             "LibraryBoook",
94             spanner.Key{intIDbook},
95             []string{"bookAvailabiliy"})
96         if err != nil {
97             if spanner.ErrCode(err) == codes.NotFound {
98                 p := map[string]interface{}{
99                     "book_error": true,
100                 }
101             }
102         }
103     }
```

Figure 16: bookIDChecker function

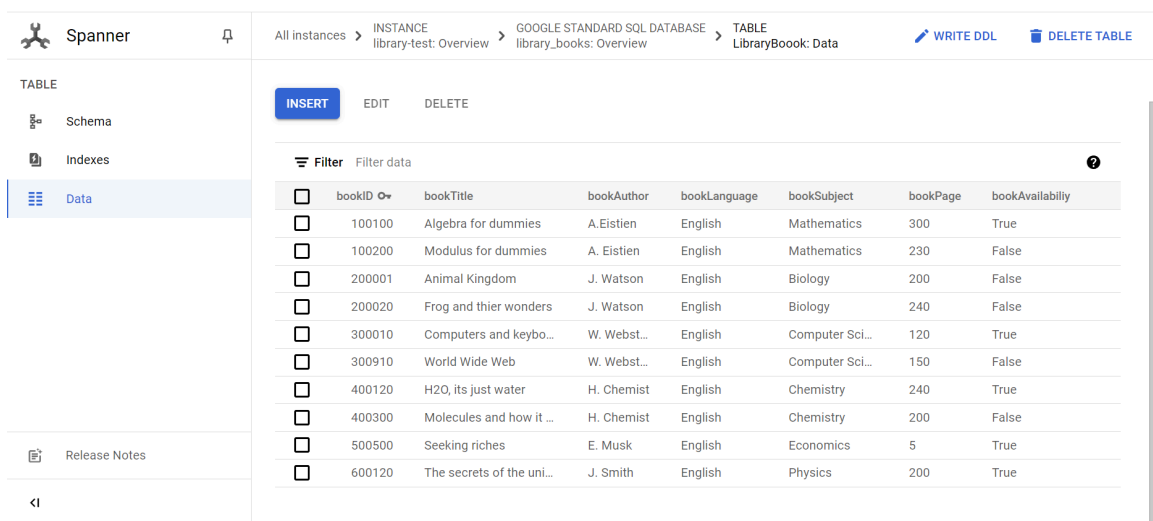
Furthermore, webhook integration allows for the creation and usage of databases and data stores to store and retrieve information required for the chatbot's functionality. For instance, a database may be used to store information about available books, their authors, and availability status. When a user queries about a specific book, the webhook can access the database to retrieve relevant information and provide it to the user through the chatbot interface.

Additionally, the webhook can be used to handle more complex tasks such as authentication, data validation, and external API calls. For example, if a user requests access to a restricted resource, the webhook can verify the user's credentials against an authentication service before granting access.

Overall, webhook integration is essential for implementing the backend logic of a chatbot, enabling it to interact with external systems, access databases, and provide dynamic responses to users' queries. It enhances the chatbot's functionality and user experience by enabling it to handle a wide range of tasks and provide accurate and personalised responses.

3.2.9 Spanner Database

In the webhook, a Spanner database is employed to store data related to the books available in the library. This database, depicted in Figure 17, functions similarly to a Structured Query Language (SQL) database. It consists of a single table named "LibraryBook," with "bookID" serving as the primary key. The table comprises only two columns: "bookID" and "bookAvailability," which are transmitted to the webhook service. While the database has the potential for further utilization, these two columns suffice for the chatbot's operation.



bookID	bookTitle	bookAuthor	bookLanguage	bookSubject	bookPage	bookAvailability
100100	Algebra for dummies	A. Eistien	English	Mathematics	300	True
100200	Modulus for dummies	A. Eistien	English	Mathematics	230	False
200001	Animal Kingdom	J. Watson	English	Biology	200	False
200020	Frog and thier wonders	J. Watson	English	Biology	240	False
300010	Computers and keybo...	W. Webst...	English	Computer Sci...	120	True
300910	World Wide Web	W. Webst...	English	Computer Sci...	150	False
400120	H2O, its just water	H. Chemist	English	Chemistry	240	True
400300	Molecules and how it ...	H. Chemist	English	Chemistry	200	False
500500	Seeking riches	E. Musk	English	Economics	5	True
600120	The secrets of the uni...	J. Smith	English	Physics	200	True

Figure 17: Spanner database

3.2.10 Data stores and Buckets

Buckets are a cloud storage service used to organize and store data in Google Cloud Platform, depicted in Figure 18. They function as containers for various types of data, such as CSVs, PDFs, or text files. For optimal accuracy when training data stores with buckets, it is recommended to have only one data type per bucket. Additionally, separating books into individual files within the bucket contributes to a more accurate data store.

As previously discussed, the data store utilizes the data stored in buckets as its training data, based on the developer's configuration. The accuracy of the data store relies on how easily the data can be collected from the files within the buckets.

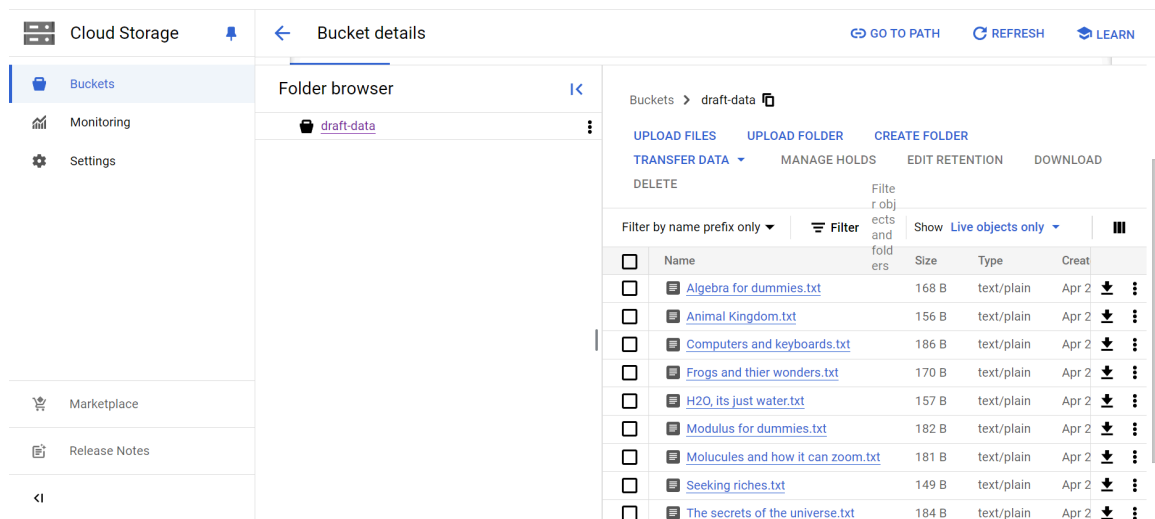


Figure 18: Buckets

3.2.11 Test and Iterate

The chatbot undergoes extensive testing using the Dialogflow console, simulator, and integration with messaging platforms to ensure performance, accuracy, and user experience. Evaluation of the chatbot's performance involves assessing its ability to

understand and respond to user queries effectively. Adjustments to the conversational flow, intents, and responses are made based on user feedback and analytics.

In Dialogflow, the test case tab allows for the creation of test cases using conversation history, as depicted in Figure 19. These test cases are used to test various aspects of the chatbot's functionality. *Figure 20* illustrates how test cases work by recording a full conversation and using it as the expected outcome when running the chatbot with the same user inputs. If the simulated run matches the expected outcome, the test case is considered successful. This approach ensures that the chatbot performs as expected and meets the specified requirements.

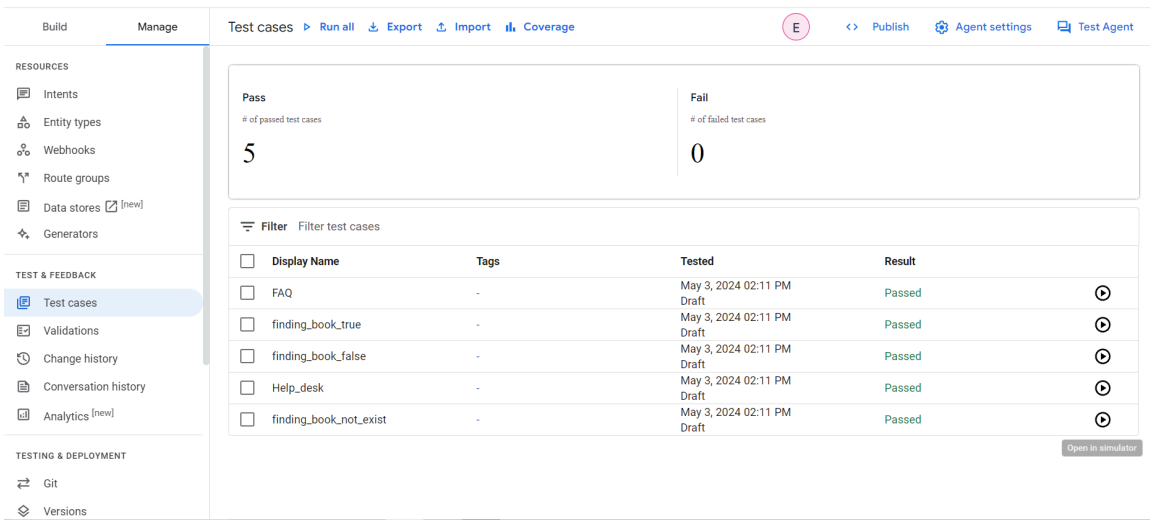


Figure 19: Test Cases

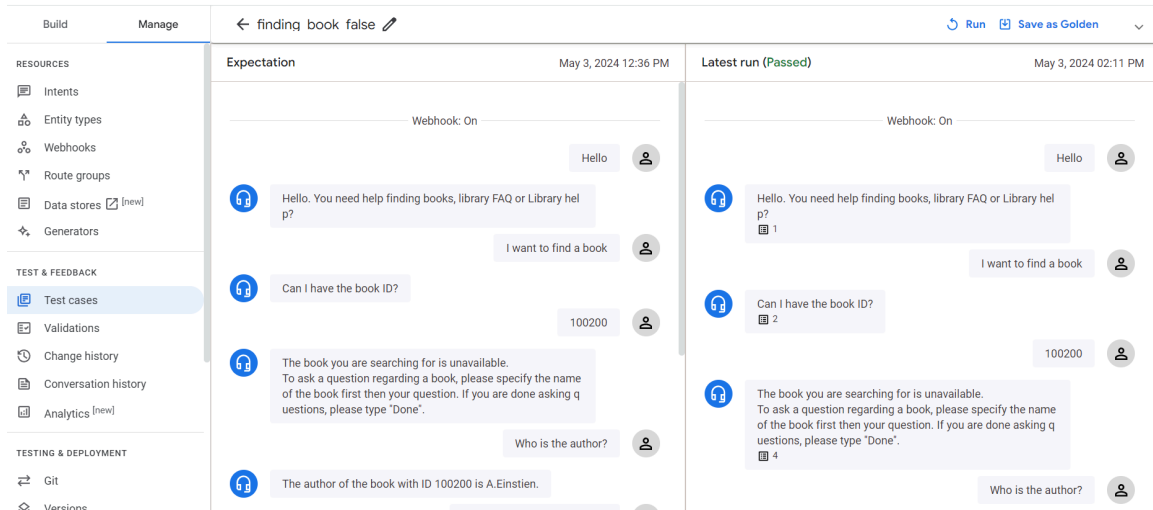


Figure 20: Examples of Test Cases

3.2.12 Deploy and Monitor

Once the chatbot meets the desired quality standards, it is deployed to the live environment. Integration of the chatbot agent into the library portal enables students to access it, as depicted in Figure 21.

The chatbot serves as a 24/7 virtual assistant for students across three main areas: Library Books, Library FAQ, and Library Help Desk. The "Library Books" allows students to easily access information about available library resources, such as inquiring about book availability and details like the title and author. This ensures students can quickly find the books they need without manual assistance.

In contrast, the "Library FAQ" provides instant answers to common questions, reducing the need for manual intervention by library staff. Students can receive immediate assistance on topics such as library hours, borrowing policies, and services offered.

For more complex issues, the "Library Help Desk" flow offers personalised support. It guides students through troubleshooting steps and provides tailored assistance, particularly for issues related to library accounts or password problems. This ensures that students receive comprehensive support for their queries, even if they require more in-depth assistance beyond simple FAQs.

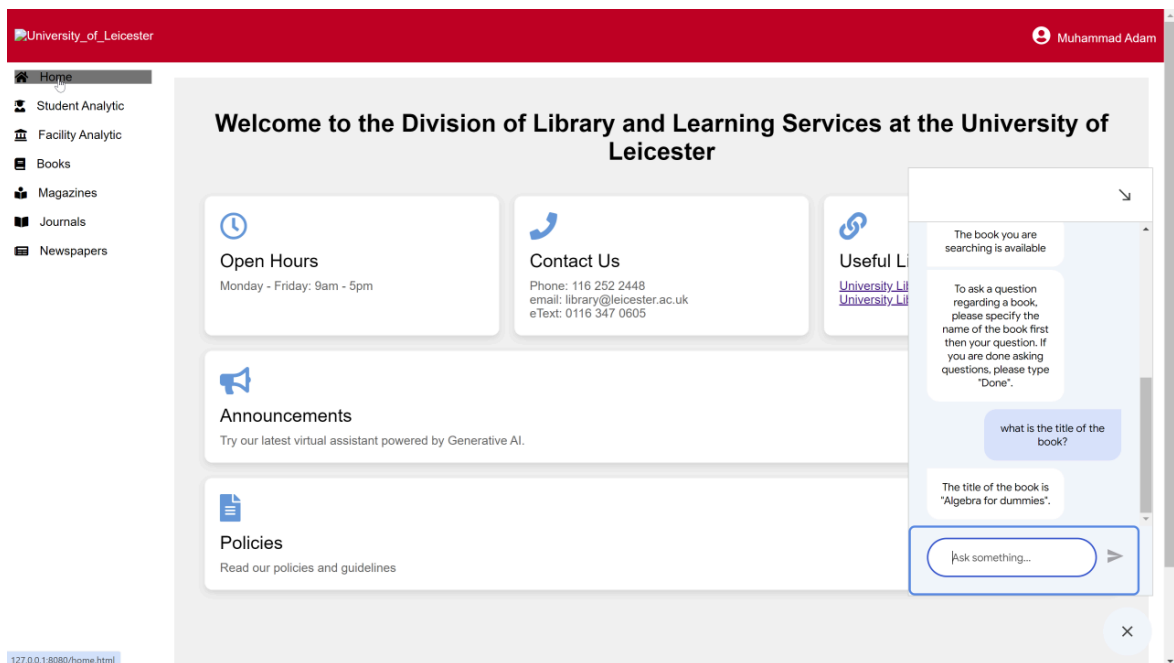


Figure 21: Chatbot Agent integrated into the library portal

The chatbot's performance and user interactions are monitored using analytics and logs provided by Dialogflow. Continuous optimization is performed based on real-world usage and user feedback to improve effectiveness over time.

To implement and display the chatbot in the library portal, the developer only has to enable the API and copy and paste the given code into the website's HTML code as seen in Figure 22. The chatbot enables students to inquire about book availability and details such as the title, author, and more.

Dialogflow Messenger

All integrations

Dialogflow Messenger brings a rich UI for Dialogflow that enables developers to easily add conversational agents to websites. [View Documentation](#)

You can also, modify the interactive visual interface, by going to Agent settings then click on Multimodal, and then click on [UI settings](#)

!

End-user interactions with the Dialogflow Messenger widget will be billed to your GCP account.

Add this agent to your website by copying the code below:

```
<link rel="stylesheet" href="https://www.gstatic.com/dialogflow-console/fast/df-messenger/prod/v1/themes/df-messenger-default.css">
<script src="https://www.gstatic.com/dialogflow-console/fast/df-messenger/prod/v1/df-messenger.js"></script>
<df-messenger
  location="us-central1"
  project_id="librarian-407620">
```

Environment: **Draft**

Disable the unauthenticated API

Try it now

Done

Figure 22: Implementing Dialogflow API

3.3 Conclusion

The methodology for developing chatbots using Dialogflow involves a systematic workflow that encompasses prompt design, model selection, customization, and request augmentation. By following these steps, developers can create chatbots that effectively understand and respond to user queries, thereby enhancing customer service experiences.

Furthermore, the integration of various features such as intents, entities, and fulfilment enable chatbots to provide tailored responses and handle diverse user interactions seamlessly. Additionally, the utilisation of webhook services facilitates backend processing and integration with external systems, ensuring that chatbots can dynamically respond to user requests.

The three primary use cases of the chatbot—Library Books, Library FAQ, and Library Help Desk—illustrate the practical application of this methodology. The Library Books feature allows users to easily access information about available library resources, such as book availability and details. The Library FAQ feature provides instant answers to common questions, reducing the need for manual intervention and ensuring consistency in responses. Lastly, the Library Help Desk offers personalised support for more complex issues, guiding users through troubleshooting steps and providing tailored assistance.

These use cases demonstrate the versatility and effectiveness of the chatbot in addressing a wide range of user inquiries related to library services. By leveraging Dialogflow's capabilities, the chatbot enhances the overall user experience by providing prompt and accurate assistance round the clock. As a result, students can access library resources more efficiently, leading to improved satisfaction and engagement.

In conclusion, Dialogflow offers a robust platform for building intelligent chatbots that can cater to a wide range of user needs. With its comprehensive set of tools and capabilities, developers can create chatbots that not only streamline customer interactions but also contribute to improved user satisfaction and overall business success.

CHAPTER 4. RESULTS AND DISCUSSION

4.1 Technical challenges

The main challenges encountered during the project included the need to learn and apply Dialogflow effectively and find the most efficient way to achieve project goals. Initially, I attempted to create a chatbot using TensorFlow and other APIs with Python, but I transitioned to using Dialogflow in December 2023, which required learning and understanding its capabilities within a short timeframe. Despite this, I was able to create several chatbot prototypes.

Another significant challenge was determining the most efficient method to train the data store with the desired output for high accuracy. I experimented with various types of data files and formats, ultimately finding that a structured text file format worked best. Additionally, separating individual books into separate files increased accuracy.

Another major challenge was learning a new programming language, Go (or Golang), for creating the webhook. This process took considerable time, and testing the webhook deployment in Dialogflow added to the complexity. While more familiar languages like Python and JavaScript were considered, Golang was ultimately chosen for its suitability in creating the webhook.

In addition to the main challenges encountered during the project, there were several additional obstacles that arose in chatbot development. One significant challenge was the integration with external systems presented another challenge. Incorporating the chatbot with existing databases, APIs, or other external systems required careful planning and implementation to ensure seamless integration. Handling different data formats,

authentication methods, and data consistency were key considerations in overcoming this challenge.

To overcome these challenges, a combination of continuous testing, user feedback analysis, and leveraging pre-built integrations and frameworks was essential. Additionally, seeking support from online communities, forums, and documentation resources provided valuable insights and solutions to common issues. Through perseverance and strategic problem-solving, these challenges were successfully navigated, leading to the development of a library chatbot for student virtual assistant solutions.

4.2 Research objectives achieved

Chatbot has become a popular research topic in recent years due to it can serve as invaluable virtual assistants in customer service, offering efficient and personalised support to users across various domains, this project use case is libraries. In the context of libraries, chatbots play a crucial role in assisting librarians, students, and patrons alike by providing quick access to information, assistance with library services, and answering inquiries in real-time. The significant contributions in this dissertation are summarised below:

1. **24/7 Assistance:** One of the primary benefits of chatbots is their availability round the clock. Librarians may not always be available to answer inquiries outside of regular hours, but a chatbot can provide immediate assistance to users at any time of the day or night. This ensures that students always have access to help and information whenever they need it. This is also in-line with the open 24 hours

policy of the library as after midnight there will be less staff available and students can ask the chatbot questions rather than trying to find the staffs.

2. **Answering Frequently Asked Questions:** Chatbots excel at handling routine inquiries and frequently asked questions (FAQs). By programming the chatbot with information about library services, policies, opening hours, and more, patrons can quickly get answers to common queries without needing to wait for a librarian to respond. This is primarily due to the nature of the questions in the FAQ section, where each question has only one correct answer. As long as the user's query accurately matches one of the FAQ questions stored in the chatbot's data store, the answer provided will always be 100% accurate.
3. **Book Inquiry:** Chatbots can help students in locating books or other library resources based on their interests or requirements. By analysing students' inquiries, the chatbot can provide detailed information about the books, enhancing the discovery process and making it more engaging and efficient.
4. **Library Helpdesk:** Chatbots can assist students in addressing issues related to the library. By analysing students' inquiries, the chatbot can provide detailed information and recommendations on how to resolve the issues, thereby enhancing the user experience in utilising the library

Table 4 presents a summary of the library chatbot use cases. Overall, when questions are relevant, meaning the information is available in the document or database, the accuracy rate is 100%. The chatbot can answer all relevant questions correctly. The detailed test results can be found at Table 5, Table 6, and Table 7.

Table 4: Library chatbots use cases result summary

Use Case	Number of Question Ask (Relevance ²)	Number of Question Answer Correctly	Accuracy
Book Inquiry	20	20	100%
Library FAQs	12	12	100%
Library Help Desk	12	12	100%

Overall, chatbot serves as invaluable virtual assistants in customer service for librarians, providing timely and personalised support to patrons while relieving the workload on library staff. By harnessing the capabilities of chatbots, libraries can improve user satisfaction, increase accessibility to resources, and create more efficient and engaging library experiences for all students.

4.3 Critical appraisal

In this critical appraisal, I will objectively analyse the entire project, reflecting on the challenges faced and the achievements made during its development. The objectives set at the beginning of the project were as follows:

1. Investigate the Impact of AI in Customer Service
2. Examine the Implementation of Chatbots in Libraries
3. Explore the Functionality of Chatbots in Libraries

² Relevance question means that the information is available in the document or the database.

4. Evaluate User Satisfaction and Acceptance
5. Identify Challenges and Opportunities
6. Propose Recommendations for Future Implementation

I have successfully achieved objectives 1, 2, 3, 5, and 6 in this project. Through the utilization of Dialogflow CX, I have explored various methods of interacting with users, each presenting its own complexity and flexibility across multiple communication scenarios. Despite time constraints, I managed to demonstrate the functionality of the database system within the chatbot for searching availability. By making adjustments to the webhook code, it can now extract multiple data points from the database, which can be utilized for any future features requiring data. Additionally, the successful integration of data stores into Dialogflow CX allows developers to easily add formatted files to the bucket data store, enabling the program to train the data store with these files. However, a significant challenge arises from the need for library staff to manually input data for every single book, rendering this method non-viable on a larger scale. While I attempted to use screenshots and web crawlers to automate data collection, these methods resulted in inaccurate AI responses to questions. One alternative approach could be to use the existing library data to populate the bucket data store, potentially expediting the process, though this may initially compromise accuracy. With some adjustments to the data, the accuracy may improve, offering a better method for adding the required data into the bucket data store.

The challenges I tried to overcome included the rigidity and simplicity of traditional chatbot implementations. While there are several Python APIs well-suited for

creating chatbots, transitioning to Dialogflow CX offered a significant advantage in providing an overview of each node, simplifying troubleshooting. I see potential in implementing Dialogflow into more systems as a chatbot tool due to its complexity and flexibility, adaptable to various scenarios. Having experimented with Python APIs in the first semester, I can confidently assert that using Dialogflow enabled me to explore multiple systems and create a high-quality chatbot. This change may lead to the development of higher quality chatbots for multiple companies. I want to address the fact that the "Library Help Desk" realistically should utilize a data store as well. However, to showcase Dialogflow's full potential, I opted to solely use routes to address user inquiries. This demonstrates that developers can create functioning chatbots without necessarily relying on webhooks and databases, though their addition can enhance the chatbot's quality. In terms of objective number 1, I conducted extensive research on how AI impacts customer service, but I feel it lacks concrete data. I hope that in the future, this chatbot, once polished and implemented, can positively impact the customer service of the library website. As mentioned previously, the introduction of a chatbot enables users to ask questions and receive instant answers without the need to contact staff via email or other means

While I successfully achieved most objectives, I did not get the opportunity to test the program with users to evaluate their satisfaction as I plan for objective 4. Integrating the chatbot into the library system for user feedback collection is a potential solution for future development. Additionally, I have several implementations I would like to see integrated into the current project, including the ability for the chatbot to communicate

with administrators or library staff, and the implementation of data analysis to identify popular books or FAQs.

Regarding objective number 6, there are several implementations I would like to integrate into the current project. The primary implementations include enabling the chatbot to communicate with the administrator or library staff, and utilizing the data collected from the chatbot to perform statistical analysis on various topics such as the most popular book or FAQ. This analysis would provide insight into the issues students using the library are facing and help determine which books require additional copies. Additionally, implementing a feedback system would be beneficial to gather user preferences and inform the library on how to meet those expectations. Other improvements will be detailed in the Future Work section at the end of this paper.

My main challenge was not using the Dialogflow system from the beginning of my project. This resulted in some ideas being abandoned in favor of focusing on the core concepts of the chatbot. Additionally, my lack of understanding of the Golang language posed a significant obstacle, as it hindered my ability to comprehend the issues encountered during the chatbot's development and find solutions for them. Furthermore, poor time management contributed to the slow progress of the project, compounded by the numerous coursework demands throughout the semester. However, I successfully created a website to deploy the chatbot, which supplements its functionality, particularly through library book text file creation. Despite these challenges, the final version of the

chatbot has achieved the primary objective of showcasing the flexibility and potential of Dialogflow in creating an AI chatbot for customer services.

CHAPTER 5. CONCLUSION AND FUTURE WORKS

5.1 Conclusion

In conclusion, this dissertation has explored the integral role of artificial intelligence (AI) in reshaping customer service, with a specific focus on the development and implementation of chatbots using Dialogflow. Throughout the study, we have discussed the definition and diverse applications of AI in customer service, emphasising its capacity to automate processes, improve user experiences, and enhance accessibility across various industries.

The implementation of chatbots using Dialogflow has been examined in detail, with a thorough exploration of its design elements, including intents, entities, and fulfilment. Intents, serving as the backbone of conversational design, categorise user intentions and guide the chatbot's responses, while entities extract relevant information from user inputs. The differences between Dialogflow ES and Dialogflow CX have also been elucidated, with Dialogflow CX emerging as a more advanced and flexible option for complex conversational flows.

Moreover, I have delved into practical considerations of using Dialogflow, such as training phrases, parameter extraction, and webhook integration, to ensure accurate and effective interactions between users and chatbots. The research methodology involved learning and utilising Dialogflow CX to develop sophisticated chatbots, prioritising ease of use and maintenance for the client.

Three distinct use cases were explored in the development of the chatbots: Library Books, Library FAQ, and Library Help Desk. The Library Books flow allows users to inquire about book availability and details, while the Library FAQ provides instant

answers to common questions, reducing the need for manual intervention. The Library Help Desk flow offers personalised support for more complex issues, guiding users through troubleshooting steps and providing tailored assistance, such as resolving library account or password issues.

The results of the implementation demonstrated the effectiveness of the chatbots in improving user engagement and streamlining library customer service processes. Based on test results as shown in Table 4, the chatbots' ability to provide high accuracy and timely assistance, this indicates that the solution can lead to increased efficiency and productivity within the library environment.

Looking ahead, there are several opportunities for future work in chatbot development and AI in customer service. Further research could explore advanced natural language understanding (NLU) techniques, integration with emerging technologies like voice assistants, and addressing ethical considerations and privacy concerns surrounding chatbot usage. Overall, this dissertation has provided valuable insights into the evolving landscape of AI-driven customer service and lays the groundwork for continued innovation in this field.

5.2 Future Work

While this dissertation has provided insights into the development and implementation of AI-driven chatbots, there are several avenues for future research and improvement:

1. **Enhanced Natural Language Understanding:** Further research could focus on improving the natural language understanding capabilities of chatbots to

better comprehend user queries, including slang, colloquialisms, and complex language structures.

2. **Personalization and Context Awareness:** Future chatbots could be enhanced to provide more personalised responses based on user preferences, history, and context. Incorporating contextual awareness features can enable chatbots to understand the user's current situation and tailor responses accordingly.
3. **Integration with Emerging Technologies:** Chatbots can be integrated with emerging technologies such as augmented reality (AR) and virtual reality (VR) to provide immersive and interactive customer experiences. Research in this area could explore how chatbots can enhance user engagement and satisfaction through these technologies.
4. **Ethical Considerations:** As chatbots become more prevalent in customer service, it is essential to consider ethical implications such as privacy, bias, and transparency. Future research should focus on developing ethical guidelines and frameworks for the design and deployment of AI-driven chatbots.
5. **Multilingual and Multimodal Support:** Expanding chatbots to support multiple languages and modalities, such as voice and text, can increase accessibility and usability for diverse user populations. Future work could explore techniques for multilingual and multimodal understanding and response generation.
6. **More Services Implementation:** As written in the Critical Appraisal, the implementation of communication between the chatbot and library staff,

statistical analysis and a feedback system would further enrich the customer service for users and give insight to the library staff. These concepts could be expanded as the chatbot continues to grow.

In summary, continued research and development in AI-driven chatbots hold great potential for revolutionising customer service, providing more efficient, personalised, and user-friendly interactions. By addressing the aforementioned areas of future work, we can further advance the capabilities and effectiveness of chatbot technology in meeting the evolving needs of users and businesses alike.

APPENDICES

APPENDIX 1. LIBRARY PORTAL SYSTEM ARCHITECTURE

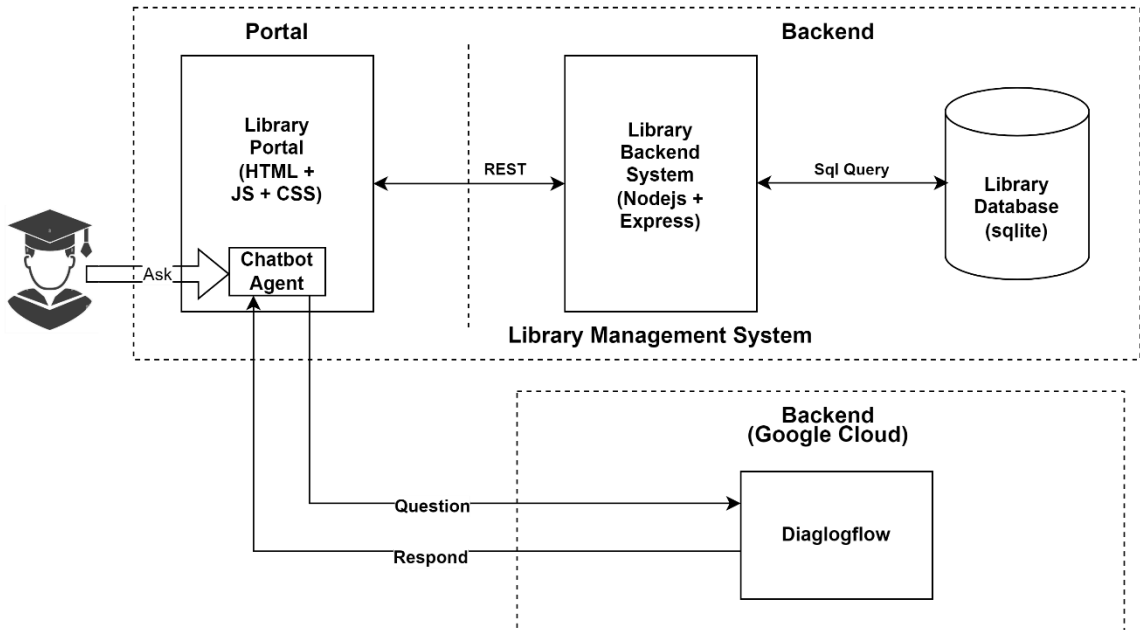


Figure 20: Library Portal System Architecture

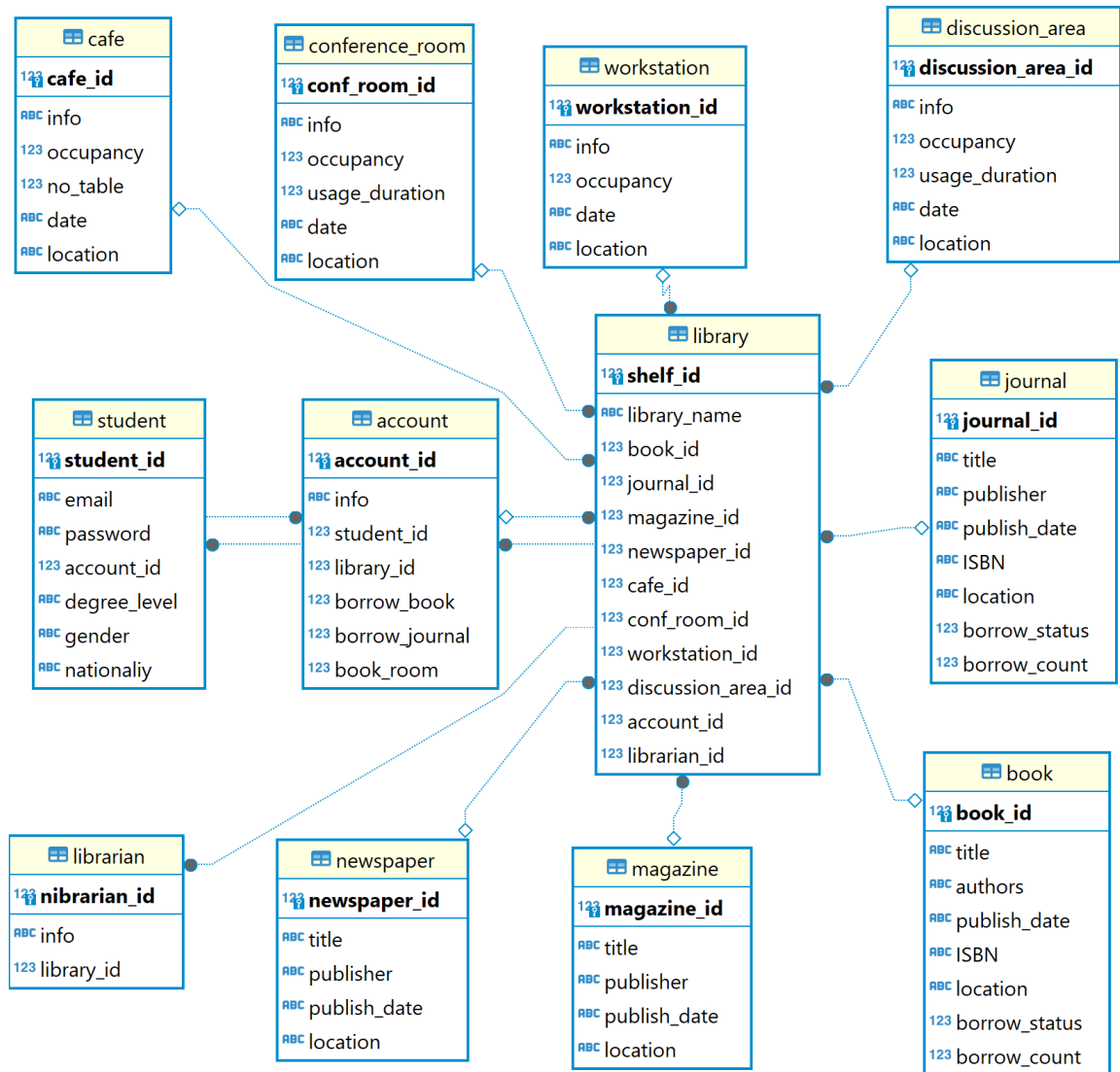


Figure 21: Entity Relationship Diagram (ERD) for the Library Management System

APPENDIX 2. CHATBOT SYSTEM TEST SUMMARY

1. Library Inquiry Conversation

Table 5: System Test Result for the Library Chatbot Cook Inquiry

	Question	Answer	Result / Comments
1	help me find a book	Can I have the book ID?	Correct
2	100100	The book you are searching is available	Correct
3	What is the title of the book?	The title of the book is "Algebra for dummies". Is there anything else I can help you with?	Correct
4	Who are the authors?	The author of the book "Algebra for dummies" is A.Einstein.	Correct
5	please describe the book content?	The book "Algebra for dummies" is a fast track to learn mathematics. It is written in English and has 300 pages.	Correct
6	Is the book available in the library?	Yes, the book "Algebra for dummies" is available in the library.	Correct
7	Is the book available in spanish?	Say that one more time?	Correct, no description for the book in Spanish language
8	Is the book language in Spanish?	The book "Algebra for dummies" is available in English.	Correct
9	What is the table of content for the book?	Sorry, could you say that again?	Correct, no table of content in the book description
10	Tell me if I can purchase the book?	Yes, you can purchase the book "Algebra for dummies".	Correct

2. Library FAQs Conversation

Table 6: System Test Result for the Library Chatbot FAQs Inquiry

	Question	Answer	Result / Comments
1	When does the library close?	It is open 24 hours each day	Correct
2	How can I borrow a book?	You can go to the counter to borrow a book	Correct
3	Can I access databases from home?	Almost all of our databases are accessible from off campus. You can access them using our library web page.	Correct
4	Is printing & photocopying available in the library?	Yes. You can find the printing machines on each floor of the library.	Correct
5	Where do I return books?	There are clear places where you can deposit borrowed books in the library.	Correct
6	What is the library policy on book return?	I didn't get that. Can you repeat?	Correct. The policy is not in FAQ.

3. Library Help Desk Conversation

Table 7: System Test Result for the Library Chatbot Help desk

	Question	Answer	Result / Comments
1	I have library account issue?	Did you forget your password?	Correct
2	yes	Can I collect your email?	Correct
3	adam@gmail.com	I have sent it to the administrator. You will get an email shortly.	Correct
4		Is there anything else that I can help with? If you want to ask another question, do not hesitate to ask.	Correct
6	My card cannot access the library?	I didn't get that. Can you repeat?	Correct. No part of the flow.

REFERENCES

- [1] Oxford English Dictionary, "Artificial Intelligence," Retrieved April 26, 2024, from https://www.oed.com/dictionary/artificial-intelligence_n?tl=true
- [2] AI watch defining Artificial Intelligent, Research Centre (JRC) Technical Report, the European Commission's science and knowledge service, 2020. [Online]. Available: https://eprints.ugd.edu.mk/28047/1/3.%20jrc118163_ai_watch_defining_artificial_intelligence_1.pdf
- [3] Y. Xu, C. Shieh, P. V. Esch, and I. Ling, "AI Customer Service: Task Complexity, Problem-Solving Ability, and Usage Intention," *Australasian Marketing Journal*, vol. 28, no. 4, pp. 189-199, November 2020. [Online]. Available: <https://doi.org/10.1016/j.ausmj.2020.03.005>
- [4] J. Bowman, "How Artificial Intelligence is Used in Customer Service," *The Motley Fool*. Retrieved November 20, 2023, from <https://www.fool.com/investing/stock-market/market-sectors/information-technology/ai-stocks/ai-in-customer-service/#:~:text=One%20popular%20example%20of%20AI,about%20their%20products%20and%20services>
- [5] Oxford English Dictionary, "Chatbot," Retrieved April 26, 2024, from https://www.oed.com/dictionary/chatbot_n?tl=true
- [6] IBM, "What is a chatbot?" Retrieved April 26, 2024, from <https://www.ibm.com/topics/chatbots>
- [7] A. M. Turing, "Computing Machinery and Intelligence," *Mind*, vol. 59, no. 236, pp. 433–460, 1950. [Online]. Available: <http://doi.org/10.1093/mind/lix.236.433>
- [8] J. Weizenbaum, "ELIZA - A computer program for the study of natural language communication between man and machine," *Communications of the ACM*, vol. 9, no. 1, pp. 36–45, 1966. [Online]. Available: <http://doi.org/10.1145/365153.365168>
- [9] OpenAI, "GPT-4 Technical Report," 2024. [Online]. Available: <https://arxiv.org/pdf/2303.08774.pdf>
- [10] A. Gupta, D. Hatwar, and A. Vijayakumar, "Introduction to AI Chatbots," *International Journal of Engineering Research & Technology (IJERT)*, vol. 9, no. 07. [Online]. Available: <https://pdfs.semanticscholar.org/f5f4/746acffef08df37f184cb6acc0505362ea9b.pdf>
- [11] Business Insider, "Global Chatbot Market Anticipated to Reach \$9.4 Billion by 2024 - Robust Opportunities to Arise in Retail & eCommerce," Retrieved April 26, 2024, from <https://markets.businessinsider.com/news/stocks/global-chatbot-market-anticipated-to-reach-9-4-billion-by-2024-robust-opportunities-to-arise-in-retail-e-commerce-1028759508>
- [12] Market Research Future, "Increased understanding and benefits of chatbots over traditional customer support solutions," Retrieved April 26, 2024, from https://www.marketresearchfuture.com/reports/chatbots-market-2981?utm_term=&utm_c

[ampaign=&utm_source=adwords&utm_medium=ppc&hsa_acc=2893753364&hsa_cam=20298941735&hsa_grp=151951244833&hsa_ad=663291708226&hsa_src=g&hsa_tgt=dsa-2088470572500&hsa_kw=&hsa_mt=&hsa_net=adwords&hsa_ver=3&gad_source=1](https://www.google.com/adwords/campaigns/details?utm_source=adwords&utm_medium=ppc&hsa_acc=2893753364&hsa_cam=20298941735&hsa_grp=151951244833&hsa_ad=663291708226&hsa_src=g&hsa_tgt=dsa-2088470572500&hsa_kw=&hsa_mt=&hsa_net=adwords&hsa_ver=3&gad_source=1)

[13] Google, "Dialogflow CX documentation," Retrieved April 26, 2024, from <https://cloud.google.com/dialogflow/cx/docs>

[14] M. C. Sung, "Development of Prospective Teachers' Adaptive Expertise in AI Chatbots: Comparative Analyses of Google Dialogflow ES and CX," ResearchGate, 2022. [Online]. Available: https://www.researchgate.net/publication/361331741_Development_of_Prospective_Teachers'_Adaptive_Expertise_in_AI_Chatbots_Comparative_Analyses_of_Google_Dialogflow_ES_and_CX

[15] Google, "Overview of Generative AI on Vertex AI," Retrieved April 26, 2024, from <https://cloud.google.com/vertex-ai/generative-ai/docs/learn/overview>

[16] Google, "Dialogflow CX agent types and editions documentation," Retrieved April 26, 2024, from <https://cloud.google.com/dialogflow/docs/editions>

[17] Google, "Dialogflow CX conversational intent documentation," Retrieved April 26, 2024, from <https://cloud.google.com/dialogflow/cx/docs/concept/intent>

[18] Google Cloud, "Dialogflow documentation," Retrieved April 26, 2024, from <https://cloud.google.com/dialogflow/docs>

[19] Google Cloud, "Cloud Storage buckets," Retrieved April 26, 2024, from <https://cloud.google.com/storage/docs/buckets#:~:text=Buckets%20are%20the%20basic%20containers,folders%2C%20you%20cannot%20nest%20buckets.>