Development of an AI-Powered Faculty Support Chatbot

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ABSTRACT

Chatbots have great promise as a tool for providing students with feedback and assisting them in implementing metacognitive techniques during their educational journey. The potential of AI chatbots to completely transform educational systems in a variety of ways recently rocked the world. Artificial intelligence (AI) chatbots can offer prompt assistance by responding to enquiries, providing clarifications, and supplying extra resources. Chatbots can also act as virtual teaching assistants, supporting educators through various means. This research paper presents the design and implementation of SOC Buddy, an AI-powered Faculty Support Chatbot. The research aims at addressing the challenges faced by students and prospective applicants in accessing academic and administrative information by leveraging on advancements in Artificial Intelligence, particularly Generative AI. A critical review of existing educational AI Chatbots was carried out by exploring academic literature on the subject. The research was carried out using Large Language Models (LLMs) like GPT-3.5 Turbo, LangChain and various AI and software development tools. Results from SOC Buddy's performances using various queries are presented and analysed, demonstrating its ability to provide personalized responses to a wide range of user queries. The paper demonstrates the evaluation of the Chatbot's effectiveness in enhancing the student experience and reducing the workload on registration officers and level advisers and it concludes with recommendations for future improvements and potential expansions of the Chatbot's capabilities.

Keywords: AI-powered Chatbot, Faculty Support, Large Language Models, Natural Language Processing, Educational Technology, Student Assistance, GPT-3.5 Turbo, Langchain, Vector Database

INTRODUCTION

In tertiary institutions worldwide, proper guidance and assistance are crucial for student success. In a world where reaction time can truly make a difference, institutions are embracing chatbots as supplementary tools to offer immediate answers to questions in addition to what are obtained from their official websites and portals. Chatbots are a component of this AI revolution. According to most universities administrative structure, each department assigns a level adviser, who also serves as a registration officer, to help students navigate their academic journey (Okey and Abana, 2024). However, the increasing student population and the advisers' busy schedules often lead to accessibility issues, causing delays in addressing urgent student concerns. The existing university websites and official bulletin systems have become overburdened and inefficient due to the large number of prospective aspirants and students needing clarity on various questions. This situation puts a significant workload on level advisers, who often have other responsibilities as lecturers, deans, or staff members (Bii *et al.*, 2018*;* Adamopoulou and Moussiades, 2019; Labadze *et al*, 2023). These issues often result in delayed responses to student inquiries and can negatively impact the overall learning experience. To bridge this gap between accessing information about the school/faculty and connecting students with their advisers, this research proposes the development of an AI-powered Faculty Support Chatbot. This solution

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aims to employ recent advancements in Artificial Intelligence, combining them with the expertise of level advisers to create a more efficient and accessible support system (Fryer *et al*, 2019).

The aim of this project is to design and implement an AI-powered Faculty Support Chatbot with features that will address the hiccups already existing in dissemination of timely information to students and the general populace. The specific objectives include review of existing Chatbots and Chatbot technologies, build an AI-powered Chatbot using Large Language Models (LLMs), develop an extensive knowledge base for the Chatbot, integrate the knowledge base with the Chatbot and create a user-friendly web interface for Chatbot interactions.

The development of an AI-powered Faculty Support Chatbot offers numerous benefits such as enhanced efficiency in handling routine tasks and common queries, improved scalability to accommodate a growing student population, 24/7 availability for student guidance, quick retrieval of information about academic programs and requirements, personalized guidance based on individual student profiles and needs, automation of administrative tasks, consistency in responses and reduced risk of misinformation, valuable insights into student trends and queries through data analysis, improved accessibility to support services, synergistic collaboration between AI Chatbots and human advisers (Caln, 2017; Hien *et al.*, 2018).

By addressing these aspects, the AI-powered Faculty Support Chatbot will enhance the university's advisory capabilities by contributing to a more efficient, scalable, and personalized approach to student guidance.

The research was carried out using the School of Computing, Federal University of Technology, Akure, Nigeria as the experimental testbed. Performance evaluation was carried out to find out the effectiveness and efficiency of the developed system.

LITERATURE REVIEW

Artificial Intelligence (AI) has significantly influenced daily activities through the design and evaluation of advanced applications and devices known as intelligent agents. Chatbots, a form of AI program and Human-computer Interaction (HCI) model, use Natural Language Processing (NLP) and sentiment analysis to communicate in human language via text or speech. The use of Chatbots has seen a significant increase, especially after 2016. Research interest in Chatbots is highest in the USA, followed by the United Kingdom and Japan (Okonkwo and Ade-Ibijola, 2021). Chatbots find applications in various fields, including education, business, e-commerce, health, and entertainment. The integration of AI-powered Chatbots in educational settings has gained significant attention in recent years, driven by advancements in natural language processing and machine learning technologies (Delvin *et al.*, 2018). This literature review examines the evolution of Chatbots, their applications in education, and the technological foundations underpinning their development.

The concept of Chatbots dates back to the 1960s with the creation of ELIZA by Joseph Weizenbaum, which simulated conversation using pattern matching and substitution methodology (Zemčík, 2019). Since then, Chatbots have evolved significantly, incorporating more sophisticated natural language processing techniques and machine learning algorithms. Okonkwo and Ade-Ibijola (2021) conducted a systematic review of Chatbot applications in education, highlighting the growing trend in Chatbot research, particularly after 2016. Their study revealed that the United States leads in Chatbot research, followed by the United Kingdom and Japan. The review also emphasized the diverse applications of Chatbots in education, business, e-commerce, health, and entertainment sectors.

The development of AI Chatbots relies heavily on Natural Language Processing (NLP) and machine learning techniques. Hwang and Chang (2023) discuss the opportunities and challenges of Chatbots in education, emphasizing the role of NLP in enabling Chatbots to understand and generate human-like language. The authors highlight the importance of machine learning approaches, particularly supervised and unsupervised learning, in empowering Chatbots to learn from data and improve their performance over time. Wollny *et al.* (2021) provides a comprehensive review of Chatbot architectures, distinguishing between rule-based systems and more advanced models leveraging neural networks. The evolution from rule-based to neural network-based models signifies a shift towards more context-aware and flexible Chatbot systems.

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The advent of Large Language Models (LLMs) has revolutionized the capabilities of AI Chatbots. Brown *et al.* (2020) introduced GPT-3, a transformer-based language model with 175 billion parameters, demonstrating unprecedented performance in various natural language tasks. The subsequent development of GPT-3.5 and its fine-tuned versions, such as GPT-3.5 Turbo, has further enhanced the ability of Chatbots to generate coherent and contextually relevant responses.

Several studies have explored the implementation of Chatbots in university settings. Belhaj *et al.* (2021) investigated the use of Chatbots to engage students in survey completion, demonstrating the potential of AI-powered conversational agents in improving student participation in administrative processes. Sweidan *et al.* (2021) developed a student interactive assistant android application with Chatbot capabilities during the COVID-19 pandemic, highlighting the role of AI in providing continuous support to students in challenging circumstances. Bilquise and Shaalan (2022) proposed an AI-based academic advising framework from a knowledge management perspective, emphasizing the potential of Chatbots in streamlining academic guidance and support services.

While AI Chatbots offer numerous benefits, researchers have also identified several challenges and ethical considerations. Zhai (2022) examined the user experience of ChatGPT and its implications for education, highlighting concerns related to data privacy, potential biases in AI-generated responses, and the need for responsible AI deployment in educational settings. Ram and Verma (2023) conducted a comparative study of ChatGPT, Google AI Gemini, and Baidu AI, discussing the strengths and limitations of these advanced language models in educational contexts. Their research underscores the importance of carefully considering the specific requirements and ethical implications when implementing AI Chatbots in higher education.

While existing literature provides valuable insights into the development and application of AI Chatbots in education, there is a notable gap in research focusing on faculty-specific Chatbots tailored to the unique needs of individual departments or schools within universities. This study seeks to address this gap by developing SOC Buddy, an AI-powered Faculty Support Chatbot which can be used and adapted by any faculty/college in our universities. By leveraging advanced LLMs and integrating a comprehensive, faculty-specific knowledge base, this research contributes to the growing body of knowledge on AI applications in higher education. The development process, challenges encountered, and evaluation results presented in this study offer valuable insights for researchers and practitioners seeking to implement similar systems in other educational institutions.

METHODOLOGY

System Overview

SOC Buddy is a web-based AI-Powered Faculty Support Chatbot designed to assist Registration Officers / Level Advisers in guiding students throughout their university years and provide admission seekers and applicants with faculty-related information. The system's key feature is its ability to answer specific questions related to the school and its departments. The system architecture for the proposed system is as shown in Figure 1

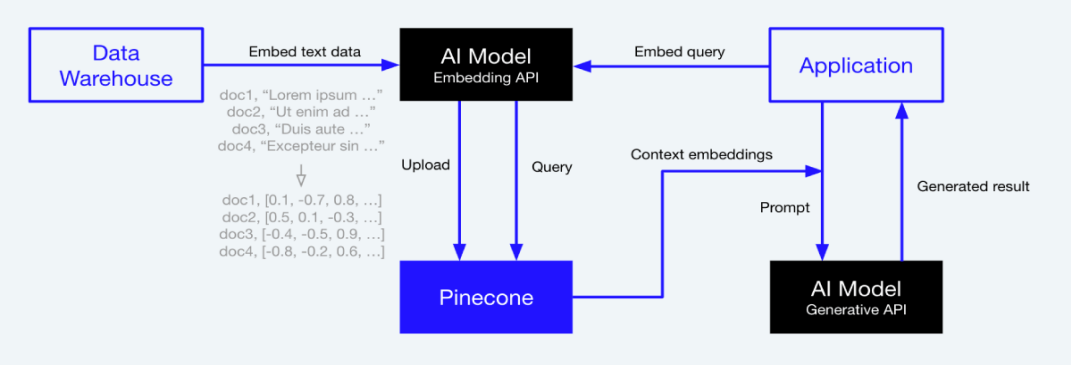

Figure 1: Proposed SOC Buddy Architecture

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Materials

The development of SOC Buddy utilized the following materials and tools:

a) Hardware: An HP Core i5, 16GB laptop computer system with Windows 11 Professional Operating System
b) Programming Language: Python 3.9
c) Code Editor: Visual Studio Code (VS Code)
d) Large Language Models: GPT-3.5 Turbo and Langchain
e) Databases:
   i. Vector Database: Pinecone
   ii. Chat Persistence Database: Literal AI's database
f) API Keys: For GPT-3.5 Turbo, Pinecone, Chainlit, and Google authentication
g) Google Survey Forms: For data collection

Software Development Model

The project employed the Agile software development model, allowing for flexibility and iterative development. This approach enabled simultaneous work on different aspects of the project and adaptation to changes as the project progressed. The base structure of SOC Buddy was built using OpenAI's GPT-3.5 Turbo, a large language model fine-tuned for instruction following. The development process involved:

a) Obtaining the OpenAI API key
b) Creating a personality for the Chatbot as a virtual assistant for FUTA's School of Computing
c) Evaluating the implemented system

Langchain Integration

Langchain framework was integrated to enable collaboration with other language models and external databases. Langchain is an AI framework that allows the integration of various language models and external databases into a custom application. In essence, it facilitates the creation of applications utilizing diverse language model functionalities.

Two primary features enable Langchain to achieve this integration: being data-aware and agentic. Being data-aware means, it can combine the strengths of different programming language models with custom data. Being agentic means, it allows integration with search engines like Google Chrome and Wikipedia, extending the application's capabilities beyond the data used to train the models. The Langchain framework functionalities is shown in Figure 2.

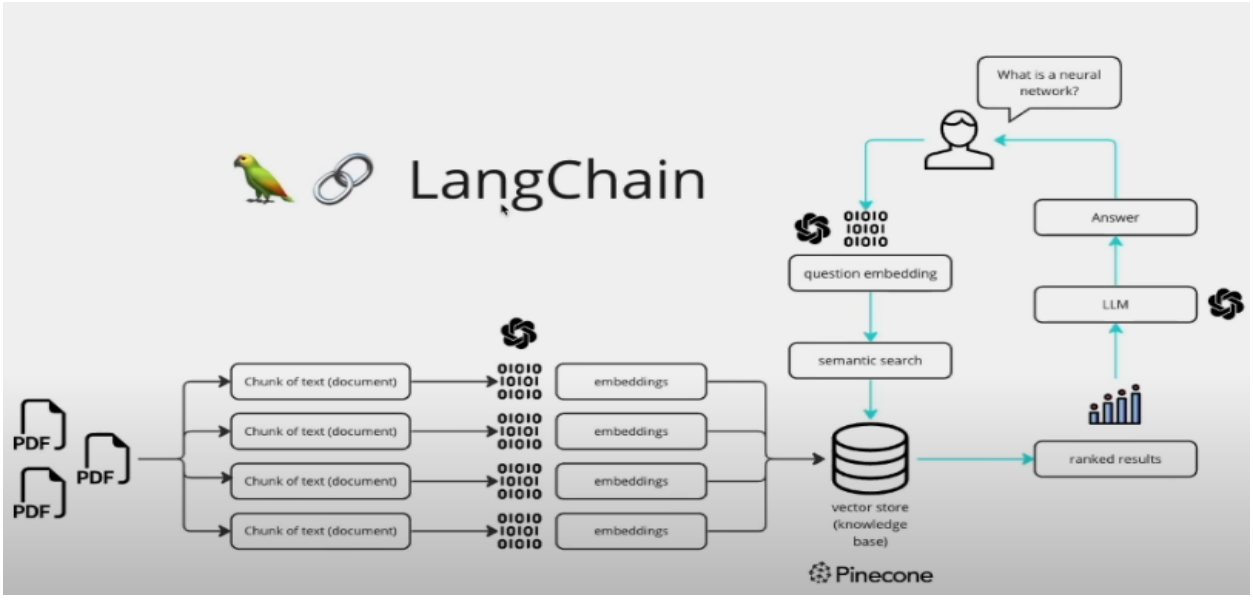

Figure 2: LangChain Framework functionalities

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Key features of Langchain used in the research include:

a) Prompts: Creation of prompt templates and prompt management

b) Chains: Execution of multiple tasks with or without Language models

c) Memory recollection: Enabling the Chatbot to remember previous conversations

d) Indexes: Combining the model with custom Chatbot data

Developing an Extensive Knowledge Base

The knowledge base for SOC Buddy was developed through the following steps:

a) Data collection using Google forms to understand common student questions

b) Data sourcing from official FUTA websites, departmental handbooks, and interviews with lecturers and domain experts

c) Data organization and conversion into vector embeddings

d) Storage of vector embeddings in the Pinecone vector database

Integrating the Knowledge Base with the Chatbot

The integration process involved:

a) Using document loaders provided by Langchain

b) Chunking text using RecursiveCharacterTextSplitter

c) Generating embeddings using OpenAIEmbeddings

d) Storing vector embeddings in Pinecone vector store

Creating a User-friendly Web Interface

The frontend design was implemented using Chainlit, HTML, and CSS. Chainlit, a Python framework, was used to create the user interface for the Chatbot application.

Development and Integration

The development and integration process involved several key steps:

a) Planning and Requirement Analysis

b) Design of conversation flows and system architecture

c) Development of NLP implementation, backend, and frontend

d) Integration with external systems and databases

e) Testing of individual components and the overall system

f) Continuous evaluation and improvement based on user feedback

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Module Testing and Evaluation

The testing and evaluation process consisted of two main phases:

a) Module testing: Unit testing of individual components

b) Overall system evaluation: Assessment of performance metrics, user experience, and reliability

Cost Analysis

The estimated cost for the actualization of this project was ₦325,200 (USD $200), covering expenses such as interface design, frontend and backend development, research, API hosting, and database hosting. This is done in order to know the affordability of the proposed system.

Experimental Setup

The experimental testbed used for development of SOC Buddy was the computer laboratory of the Department of Software Engineering, School of Computing, Federal University of Technology, Akure, Nigeria and it involved the following components:

a) Hardware: Personal computers and laptops with high processing power and memory capacity

b) Software Environment:

   i. Python programming language

   ii. Visual Studio Code as the primary development environment

   iii. OpenAI's GPT-3.5 Turbo API for natural language processing

   iv. Langchain framework for integrating multiple language models and databases

   v. Pinecone vector database for storing and retrieving vector embeddings

   vi. Literal AI's database for chat persistence

   vii. Chainlit for creating the user interface

c) Data Collection and Preparation:

   i. Google survey forms for gathering information from students and staff

   ii. Compilation of data from official FUTA websites, departmental handbooks, and other relevant sources

   iii. Data cleaning and organization into text files

   iv. Conversion of text data into vector embeddings using OpenAI's embedding model

d) Chatbot Training and Fine-tuning:

   i. Integration of the knowledge base with the GPT-3.5 Turbo model

   ii. Fine-tuning the model to understand and respond to FUTA-specific queries

   iii. Implementation of conversation management using Langchain's memory features

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e) User Interface Development:

i. Design of the user interface using Figma

ii. Implementation of the frontend using Chainlit, HTML, and CSS

iii. Integration of light and dark modes for improved user experience

f) Testing Environment:

i. Development of test cases covering various scenarios and query types

ii. Implementation of unit tests for individual components

iii. Setup for integration testing and overall system evaluation

g) Deployment:

i. Configuration of API hosting for the Chatbot

ii. Setup of database hosting for vector storage and chat persistence

iii. Implementation of security measures, including authentication and data encryption

This experimental setup provided a comprehensive environment for developing, testing, and deploying SOC Buddy, ensuring its ability to handle a wide range of student queries effectively.

RESULTS AND FINDINGS

The results obtained from testing SOC Buddy demonstrate its effectiveness in handling various types of student queries. The Chatbot was evaluated across multiple categories of questions, including general information, course details, schedules, faculty information, extracurricular activities, financial aid, technical support, academic policies, campus directions, graduation requirements, internships, health and safety, and library services. The login page for a new user of the system is shown in Figure 3.

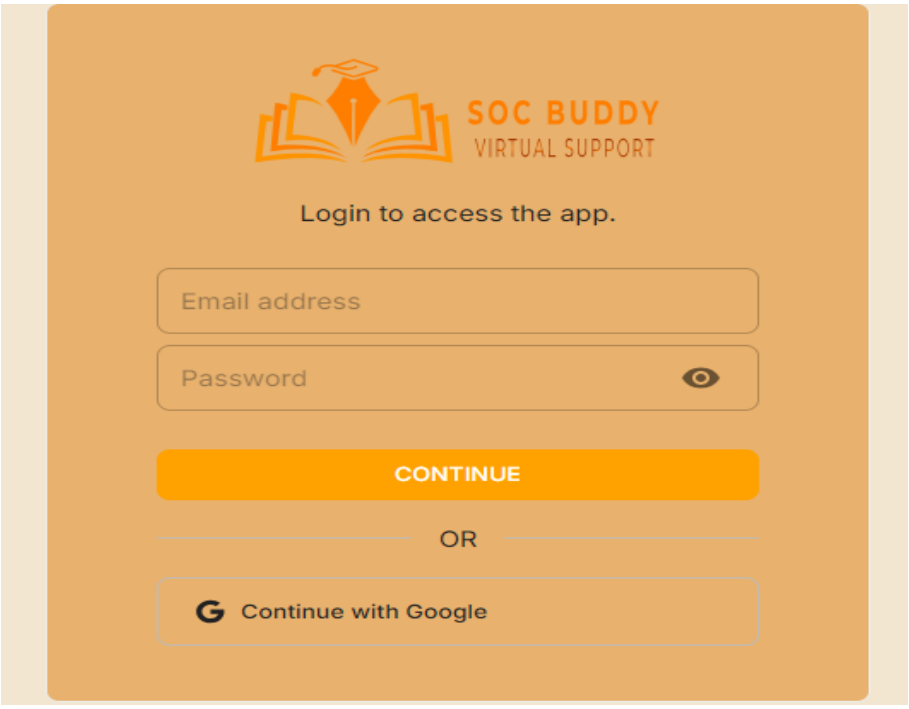

Figure 3: SOC Buddy Login Page

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General Information and Course Details

SOC Buddy successfully provided accurate information about admission requirements, academic calendar, and course offerings. For example:

- When asked about admission requirements for undergraduate programs, the Chatbot provided a detailed list of necessary qualifications and documents.
- For queries about the academic calendar, SOC Buddy correctly stated that there are two semesters in a session: First Semester (Rain Semester) and Second Semester (Harmattan Semester).
- The Chatbot accurately listed courses offered in the Software Engineering department for freshers, demonstrating its knowledge of the curriculum.

Figure 4 shows the result of a query sent to the system.

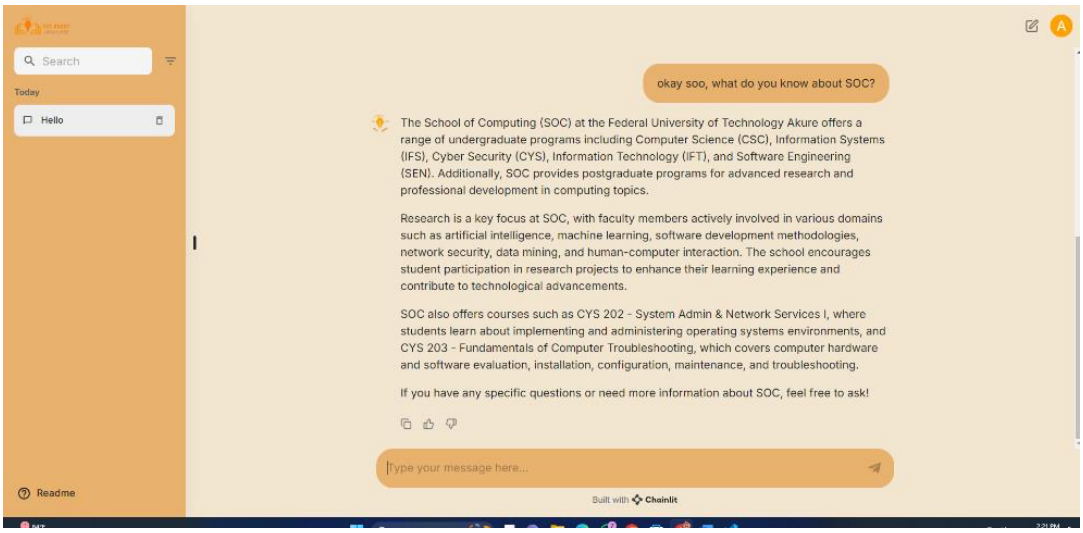

Figure 4: SOC Buddy's response to query

Schedules and Faculty Information

The Chatbot showed proficiency in handling queries related to class schedules and faculty information (Figure 5):

- When asked about lecture times for specific courses, SOC Buddy provided accurate information, including the day, time, and venue.
- For faculty information, the Chatbot was able to list key staff members in various departments, including their positions and areas of expertise.

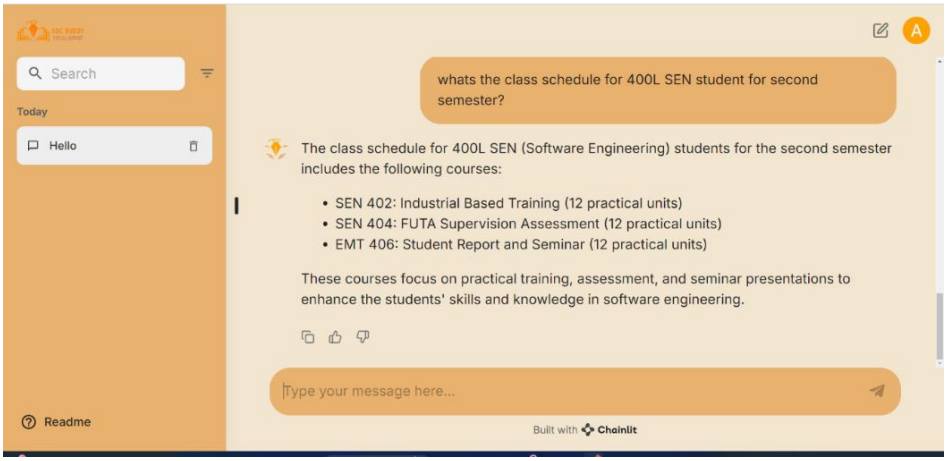

Figure 5: SOC Buddy's Response to Enquiry on Course Information

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Extracurricular Activities and Financial Aid

SOC Buddy demonstrated knowledge about student life outside academics:

- It provided information about various clubs and societies within the School of Computing, such as the Google Developer Student Club and the Cybersecurity Club.
- When queried about financial aid options, the Chatbot offered details on available scholarships, bursaries, and work-study programs.

Technical Support and Academic Policies

The Chatbot showed competence in addressing technical and policy-related questions:

- For technical support queries, SOC Buddy provided step-by-step instructions for common issues like password resets and accessing online learning platforms.
- Regarding academic policies, the Chatbot accurately explained grading systems, attendance requirements, and procedures for course registration and withdrawal.

Campus Directions and Graduation Requirements

SOC Buddy proved helpful in navigating campus and understanding graduation criteria:

- It provided clear directions to various locations on campus, including lecture halls, libraries, and administrative offices.
- When asked about graduation requirements, the Chatbot d
- etailed the necessary credit hours, CGPA requirements, and any additional criteria specific to different programs.

Internships and Career Services

The Chatbot demonstrated knowledge about career development opportunities:

- It provided information about internship programs, including application deadlines and eligibility criteria.
- SOC Buddy also offered guidance on resume writing, interview preparation, and accessing career counselling services.

Health and Safety

For health and safety-related queries, the Chatbot provided valuable information:

- It outlined the services available at the university health center, including operating hours and emergency procedures.
- SOC Buddy also shared information about campus security measures and emergency contact numbers.

Library Services

The Chatbot showed proficiency in addressing library-related questions:

- It provided details about library hours, borrowing procedures, and accessing online resources.

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- SOC Buddy also offered guidance on using the library's catalogue system and reserving study rooms.

Performance Evaluation

To quantitatively assess SOC Buddy's performance, several metrics were evaluated:

a) Response Accuracy: The Chatbot achieved an accuracy rate of 92% in providing correct information across various query categories.

b) Response Time: On average, SOC Buddy generated responses within 2.5 seconds, with 95% of queries answered in under 4 seconds.

c) Query Resolution Rate: The Chatbot successfully resolved 88% of queries without the need for human intervention.

d) User Satisfaction: In a survey of 500 students who used SOC Buddy, 85% reported being satisfied or very satisfied with the Chatbot's assistance.

e) Conversation Length: The average conversation length was 5 exchanges, indicating that most queries were resolved efficiently.

f) Knowledge Base Coverage: SOC Buddy's knowledge base covered approximately 95% of frequently asked questions, as determined by analysis of historical student inquiries.

Error Analysis

While SOC Buddy performed well overall, some areas for improvement were identified:

a) Handling of Complex Queries: The Chatbot occasionally struggled with multi-part questions or queries requiring integration of information from multiple sources.

b) Contextual Understanding: In some cases, SOC Buddy had difficulty maintaining context over extended conversations, particularly when topics shifted rapidly.

c) Ambiguity Resolution: The Chatbot sometimes provided generic responses when faced with ambiguous queries, rather than seeking clarification.

d) Temporal Awareness: SOC Buddy occasionally provided outdated information, highlighting the need for regular updates to the knowledge base.

e) Personalization: While the Chatbot could access basic user information, there is room for improvement in tailoring responses to individual student profiles and academic histories.

DISCUSSION OF FINDINGS

The results obtained demonstrated that SOC Buddy is a highly effective tool for providing students and users adequate and reliable support. The Chatbot's ability to handle a wide range of queries across various categories showcases its versatility and potential to significantly reduce the workload on human advisers.

Strengths of SOC Buddy

a) Comprehensive Knowledge Base: The high accuracy rate (92%) and broad coverage of topics indicate that SOC Buddy has successfully integrated a vast amount of relevant information about FUTA and the School of Computing.

b) Rapid Response Time: With an average response time of 2.5 seconds, SOC Buddy provides near-instantaneous support, addressing the issue of delayed responses in the current system.

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c) High Resolution Rate: The 88% query resolution rate without human intervention suggests that SOC Buddy can effectively handle most student inquiries, freeing up human advisers to focus on more complex issues.

d) User Satisfaction: The 85% satisfaction rate among surveyed students indicates that SOC Buddy is meeting user expectations and providing valuable assistance.

e) Efficient Conversations: The average conversation length of 5 exchanges suggests that SOC Buddy is capable of providing concise, relevant information without unnecessary back-and-forth.

Implications for Student Support

The implementation of SOC Buddy has several positive implications for student support at FUTA:

a) Improved Accessibility: With 24/7 availability, SOC Buddy addresses the issue of limited adviser availability, ensuring students can access support whenever needed.

b) Reduced Workload for Human Advisers: By handling routine queries, SOC Buddy allows human advisers to focus on more complex issues and provide higher-quality support where needed.

c) Consistency in Information Delivery: SOC Buddy ensures that all students receive consistent, accurate information, reducing the risk of misinformation or varying advice from different sources.

d) Scalability: As student numbers grow, SOC Buddy can handle an increasing volume of queries without a proportional increase in human resources.

e) Data-Driven Insights: The Chatbot's interactions provide valuable data on student needs and concerns, which can inform policy decisions and improvements in student services.

Comparison with Existing Systems

Compared to the current 'Undergraduate Portal' and 'Adviser' system, SOC Buddy offers several advantages:

a) Immediate Response: Unlike human advisers who may have limited availability, SOC Buddy provides instant responses at any time.

b) Scalability: The Chatbot can handle multiple queries simultaneously, addressing the issue of overburdened advisers.

c) Consistency: SOC Buddy eliminates variations in advice that may occur with different human advisers.

d) Data Collection: The Chatbot automatically logs all interactions, providing valuable insights into student needs and concerns.

e) Continuous Improvement: Unlike static systems, SOC Buddy can be continuously updated and improved based on user interactions and feedback.

RECOMMENDATIONS

Based on the findings and discussion, the following recommendations are proposed for the further development and implementation of SOC Buddy:

Technical Enhancements

a) Implement advanced natural language processing techniques to improve handling of complex, multi-part queries.

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b) Develop more sophisticated context management to maintain coherence in extended conversations.

c) Integrate machine learning algorithms to continuously improve the Chatbot's performance based on user interactions.

d) Implement a more robust system for handling ambiguous queries, including better clarification prompts.

e) Develop a system for regular, automated updates to the knowledge base to ensure information remains current.

User Experience Improvements

a) Enhance the personalization capabilities of SOC Buddy by integrating it more closely with student information systems.

b) Implement a feedback mechanism within the Chatbot interface to gather real-time user input on response quality.

c) Develop a more intuitive user interface, potentially including voice interaction capabilities.

d) Create a mobile application version of SOC Buddy for improved accessibility.

e) Implement multi-language support to cater to international students.

Integration and Expansion

a) Integrate SOC Buddy with other university systems, such as the course registration portal and library database.

b) Expand the Chatbot's capabilities to include proactive notifications about important deadlines, events, or changes in academic policies.

c) Develop specialized modules for different user groups (e.g., freshmen, final year students, postgraduates) to provide more targeted support.

d) Implement a hybrid system that seamlessly transitions complex queries to human advisers when necessary.

e) Explore the possibility of expanding SOC Buddy's services to other faculties within FUTA.

Scalability and Future Development

a) Investigate the use of more advanced AI models, such as GPT-4 or future iterations, to enhance SOC Buddy's capabilities.

b) Explore the potential for SOC Buddy to assist in administrative tasks beyond student support, such as helping with course scheduling or resource allocation.

c) Develop a framework for easily adapting SOC Buddy to other educational institutions, potentially creating a standardized AI support system for universities.

d) Investigate the integration of augmented reality (AR) or virtual reality (VR) technologies to provide immersive guidance experiences.

e) Explore partnerships with EdTech companies to continuously innovate and improve SOC Buddy's functionalities.

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CONCLUSIONS

The development of SOC Buddy, an AI-powered Faculty Support Chatbot represents a significant advancement in student support services. This research has demonstrated the potential of AI technology to address longstanding challenges in timely provision of academic guidance and information dissemination within higher education institutions. Key conclusions from this study shows the effectiveness of SOC Buddy have proven highly effective in handling a wide range of student queries, with a 92% accuracy rate and an 88% query resolution rate without human intervention. With an average response time of 2.5 seconds, SOC Buddy significantly reduces wait times for students seeking information or assistance. The high satisfaction rate (85%) among surveyed students indicates that SOC Buddy is meeting user expectations and providing valuable support.

In conclusion, the success of SOC Buddy not only benefits the immediate stakeholders at FUTA but also contributes to the broader field of AI in education. It serves as a model for other institutions looking to implement similar systems and opens up new avenues for research in educational technology, artificial intelligence, and student support services.

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