A TA-Like Chatbot Application: ATOB

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Abstract

The purpose of this research is to propose a cloud-based chatbot prototype that allows better, more convenient, and friendly interaction between TAs and students. Since not all students have the same background, we cannot use the same learning approach to solve their challenges. In addition to helping students, this research will also aid teaching assistants who assist students and instructors. As the number of students enrolled in technology-related courses proliferates, prompt support to all students is not guaranteed. For this purpose, the following are the challenges to achieving the goal: How can we ensure students answer to their questions? How can we help reduce the work of teaching assistants to answer the questions that a chatbot can do for common problems? To address the challenges, we develop ATOB. This chatbot helps students with technical issues they encounter at any given time and lends a hand to teaching assistants by taking care of the repetitive tasks typically done manually.

Keywords: Teaching Environment, Learning Environment, Chatbot, Artificial intelligence, Conversational Context, Virtual Teaching Assistants

1. INTRODUCTION

With the rise of technology, more people have opportunities to learn regardless of where they are in the world. Many institutions offer an online platform that makes learning more approachable to everyone who has internet access. With the growth of online education combined with the traditional on-site learning method, enrollment growth is increasing drastically (McGraw, 2020).

In higher education, teaching assistants (TAs) have become the norm for helping students grasp new concepts and assist with known challenges and unknown issues. The typical way for students to reach out for help is to contact TAs directly in person or through online communication platforms such as email services. However, when there is high enrollment, the approach could get beyond the limit, and TAs can be overwhelmed by the number of students who outweigh the number of TAs in a department.

This research aims to implement a prototype that allows better, more convenient, and friendly interaction between TAs and students. With this goal, this paper proposes a cloud-based chatbot application that assists students with technical problems on Hands-on Practice, Programming Exercise assignments, and the general concerns that students may have. Additionally, this research provides support to TAs to have fewer manual tasks.

Problem Statement
From 2012 to 2017, online enrollment in bachelor's and master's degrees increased by 42.59 percent (McGraw, 2020). Due to the increased number of students, we encounter the following challenge - How can we support students and reply to their questions 24/7 with the limitation of teaching assistants? Chatbots provide more benefits in various industries, especially in the education domain, which is the main focus of this paper. Georgescu (2018) mentioned that education is one of the most significant fields that chatbot plays a considerable role. Chatbots deliver conversational requirements supporting for both teachers and students.

This paper proposes a TA-like chatbot application called ATOB, the first conversational agent for the authors' school. The name comes from the word "Bot" and "TA" combined in reverse, and a "T" is dropped to keep it short. ATOB will be a helpful tool for students, TAs, and faculty. We implemented an ATOB with the help of technology tools such as Python for AI programming, Node.js for full-stack application engine, Google Cloud for cloud computing, Dialogflow for a natural language understanding platform as the primary technical stack.

Motivation
Considering the increasing number of students enrolled and the difference in time zones common in online courses, getting immediate help is not promised. In search of providing optimal assistance to students, we built a chatbot motivated and inspired by the authors' school and an author's experience of being a student and a TA.

According to Hien et al. (2018), chatbots increase user satisfaction by speeding the response time, increasing the availability to help multiple students at any given time, automating repetitive tasks, and supporting various languages. ATOB will take as much portion of the work as possible to be an assistant to TAs. This would allow students to get help much quicker. TAs can help with other tasks such as working with students with lab exercises, grading assignments, or tasks that require more hands-on support (Bavishi, 2019).

2. BACKGROUND

A chatbot is a type of Artificial Intelligent (AI) system and Human-Computer Interaction (HCI). It responds to a conversation with text or voice and understands human languages with Natural Language Processing (NLP) (Adamopoulou & Moussiades, 2020). The use of chatbots evolved for users and companies as it has many advantages, such as receiving immediate feedback, relevant communication channels, and search help (Stephanie, 2020). A chatbot helps customers with different kinds of tasks, from answering simple questions to assisting with the knowledge it gathers as the way humans would answer. Chatbots' ability to help people in other industries can be adapted to what people in the education domain seek.

In the education domain, an effective practical approach to deliver learning content to the students is crucial. In doing so, assisting when needed for help is an essential part of the teaching and learning process. An example of where a chatbot can come into support is when searching for information within the course. Sandoval (2018) mentioned that students from an educational technology program usually asked for specific content in the syllabus over time. A chatbot can help students look up information on course materials.
Moreover, chatbots can answer frequently asked questions (FAQs). According to Hien et al. (2018), one of the significant trends in learning support that chatbots can provide is that we can train them to answer FAQs. Appropriate training can be applied so that the chatbot can match correct intents and have FAQs answered immediately and conveniently. Chatbots can also be useful is when helping students solve technical problems. Teaching and learning programming languages have been a significant part of technical schools. Providing help to solve technical issues is challenging, especially in large classes when the number of TAs may not be enough to serve all students. Chatbots can play a large role in addressing this challenge.

Overall, chatbots help students answer different types of questions and problems and assist TA's and faculty, ultimately enhance the learning and teaching environment.

3. RELATED WORK

Literature Review
An example of chatbot usage is Eliza, one of the oldest and well-known chatbots created by the AI Laboratory at MIT. It was used to simulate the role of psychotherapists that people talk to when they have anxiety with exceptional performance. Eliza has become an inspiration to many developers thus far (ZEMČÍK, 2019).

There are existing works that utilize chatbots for educational purposes as well. UC Irvine proposed the chatbot that helped public services at the library teach patrons how to locate and identify resources for their research (Rice & Gregor, 2016). At Stanford University, to overcome the limitations of the TAs' human resources, a chatbot was implemented to answer questions for a class by gathering data from an online forum that students used. (Chopra, Gianforte, & Sholar, 2016). The concepts and utilization from these works are applied in our study as success stories to help students use chatbots.

In implementing these types of chatbots, constructively designing the chatbot is crucial to meet the users' needs. The following provides related works that support the foundational development of ATOB. Chopra, Gianforte, and Sholar (2016) proposed a design of the chatbot that classified questions into three categories: 1) assignment - the bot should be able to help with the technical problem, 2) conceptual - the bot should answer conceptual questions and provide students a better perception of a given concept, and 3) policy - the bot should be able to answer the general questions regarding course policy. We use this design to model how a chatbot is structured to handle students' questions.

Sandoval (2018) proposed the chatbot for an online class that can answer FAQs for the following topics: course syllabus, instructors' information, required textbooks, policies, assignment description, and services. In addition, this paper provides a better user experience with the buttons for faster replies with optional answers students can choose. The integration for this chatbot was embedded in a Learning Management System (LMS), Blackboard.

Ranoliya, Raghuwanshi, and Singh (2017) provided an accurate answer to any questions based on the FAQ dataset using Artificial Intelligence Markup Language (AIML) and Latent Semantic Analysis (LSA). Their system consisted of the broad knowledge of college admission, college information, activities happening on campus, etc. Our work also provides the general design of categorizing inputs and responding by pattern matching.
Hobert (2019) implemented a web-based chatbot alongside the code editor interface to analyze students' code syntax and format. Hobert's approach is helpful for students who want to learn new programming languages. This research is valuable to the implementation of our chatbot since technical questions can be related to code static analysis problems that students may have.

Summary
The review clearly shows that chatbots are an ideal tool for learning within the university, especially in an online learning environment. Most of the research found that chatbot implementation was used to support FAQs and the information already provided by the universities, such as grading policy, syllabus, and instructors' information. Among all the literature, a few studies discuss the chatbot's ability to support programming problems for students who want to learn new languages. Another similarity of these works is the structure of designing a chatbot. Many studies provided a similar approach that categorizes the questions into different categories. However, one aspect not mentioned in any research is integrating cloud-based software development with source code shared hosting.

Overall, these related works include theories and actual implementations that are the significant foundation of our chatbot implementation. ATOB is an all-in-one chatbot that answers simple course-related questions, FAQs, and technical questions. It also includes an automation connecting students to a third-party tool such as GitHub that initially required TAs or professors to approve requests manually.

4. APPROACH

We implement ATOB with Dialogflow that uses NLP, Natural Language Understanding (NLU), and Machine Learning (ML) to identify intents (Kavlakoglu, 2020). We also provide sentiment analysis for the conversations, which is shown in Figure 1. The utterance is divided into different categories for efficient and accurate responses. Additionally, this project integrates with a third-party source code management system, GitHub, for automation purposes to perform tasks related to students' submissions and contributions.

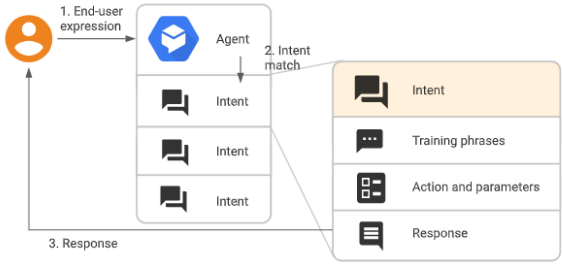

Figure 1. Dialogflow's basic flow for intent matching and responding.

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This implementation consists of Python language, which is used with Dialogflow's library for extracting and creating knowledge base data from Comma-Separated Values (CSV) files and HyperText Markup Language (HTML) FAQ pages (Dialogflow: Python Client, 2021). Gapanyuk et al. (2018) proposed this approach. Node.js is used to perform business logic and handle intents that need extra computation between Dialogflow and cloud-based backend services, including database and API via HTTP protocol (Natural Language Toolkit, 2021). Fernoagă et al. (2018) used this approach. Figure 2 shows how Dialogflow's fulfillment is handled with a Webhook accepting and returning JavaScript Object Notation (JSON) data for real-time computation.

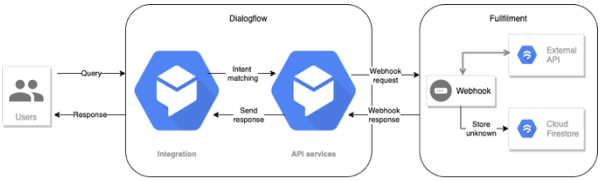

Figure 2. Processing flow for fulfillment

The chatbot's job is to get a query and calculate the best answer returned to students. The functionality that plays a massive role in helping TAs is the part provided by Node.js. It acts as a middleman who takes GitHub requests and interacts with GitHub API to send, approve, and add students to the classroom's repository for further contribution. TAs usually carry out the entire process one by one every quarter, which is time and energy-consuming. However, with the help of this functionally from the chatbot, it significantly eases the task for the TAs.

5. DATA COLLECTION

We do not have many Q&A and forum-style platforms used intensively for classes for the data collection process. The primary source of data is from email services. To gather as much data as possible, we provide a medium where all TAs and instructors put what they have had as a data source into one place. In other words, we collect data for an existing medium with emails that we have used to communicate with students. The number of emails used in this paper is as many as possible (approximately 50 emails) to mine chatbot technical and course-related information training data. This research also includes some other general information regarding the programming or concept taught in computer science classes. See Table 1 for a sample of data collected from students' emails and posts in course forums. The data is used to train the chatbot to understand the intents of students' questions. This data is essential in understanding how the chatbot is built to support students, focusing on the paper's problem statement.

Categories	Questions
Course Info	What textbook is required for this course?
	How can I contact the instructor and TAs?
	When are my assignments due?
Technical Questions	Where can I download the tools?
	I have a module error. What should I do?
	I do not see the function in Lambda.

Table 1. Sample questions that students have and might have

6. DATA ANALYSIS

We collected data and categorized them into different groups: course information, technical (hands-on practices, programming exercises, technologies used in the course), and school-related questions. The training data for technical questions come from public online sources such as stack Overflow, GitHub, and frameworks' documentations. We performed data cleaning to suit the categories for training the chatbot. Then, we matched data to correct the intent handle. We also collected statistics at each of the conversations to see if the bot answered their questions correctly. If not, the question is stored, updated to the database, and trained for new knowledge for future use. Suppose the resulting ratio of any given questions was 80 percent and higher. In that case, the bot is ready to be utilized for the intent. We visualized the knowledge result data in Figure 3 to represent the chatbot's performance at any given time.

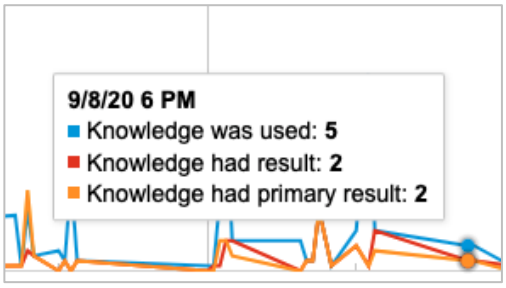

Figure 3. Knowledge result statistics

7. FINDINGS

The implementation of our chatbot is to respond to academic needs mainly for a course, CS 547 Secure Systems and Programs, helping students

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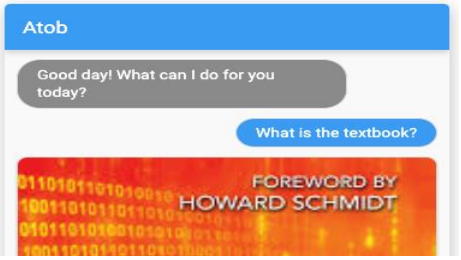
with the course policy questions and technical questions focused on Serverless Technology. The course-related documents were extracted into a CSV file with two columns: questions and answers shown in Figure 4.

The result of the data gathered and the implementation was responsive and, more importantly, answered our research question - "How can we support students 24/7 with more convenience regardless of where they are learning from?" Figures 5 and 6 represent conversations from students asking for course information such as required textbooks, assignments, and university resources. The figures show that the chatbot replied and understood what the student was asking accurately.

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questions,answers
What is course description?,"This course covers the principles and practices of secure programming. The course cov
What is the required textbook?,"The textbook for this class is Core Software Security: Security at the Source 1st
What are the chapter covered in this class?,"1. Introduction
2. The Secure Development Lifecycle
3. Security Assessment (A1): SDL Activities and Best Practices
4. Architecture (A2): SDL Activities and Best Practices
5. Design and Development (A3): SDL Activities and Best Practices
6. Design and Development (A4): SDL Activities and Best Practices
7. Ship (A5): SDL Activities and Best Practices
8. Post-Release Support (PRSA1-5)
9. Applying the SDL Framework to the Real World
10. Pulling It All Together: Using the SDL to Prevent Real-World Threats"
What are the assignments?,"The Muddiest Point (MP) - 5%
Concept Test (CT)       - 5%
Discussion Board (DB)   - 10%
Hands-On Practice (HOP) - 20%
Virtual Lab (VL)        - 30%
Knowledge Check (KC)    - 10%
Team Project (TP)       - 20%"
What is The Muddiest Point?,"Before class, students are required to finish the muddiest point activity. This activ
What is Concept Test?,"Students may be required to answer questions called Concept Tests, which allows peers to te
What is Discussion Board?,"Basically, students post their answers and responses to two other students' ones in the
What is Hands-on Practice?,Students will learn and practice either specific tools or languages pertinent to their
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Figure 4. The knowledge base in CSV format

Figure 5. Responses to course questions

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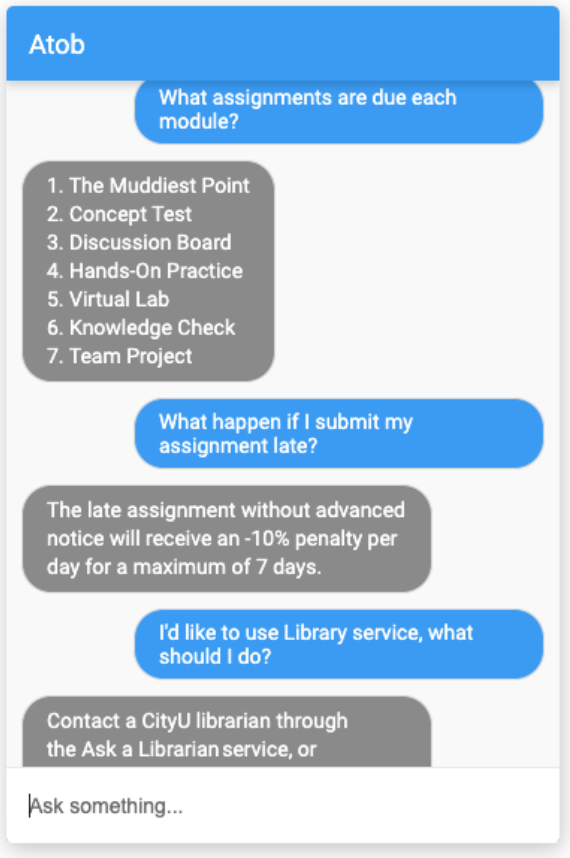

Figure 6. Responses to university's policy

8. CONCLUSIONS

The proposed research presented in this paper seems to have answered the problem statement with positive satisfaction. We show a cloud-based chatbot application that assists students with technical problems on Hands-on Practice and Programming Exercise assignments and the general concerns that students may have. Additionally, this research provides support to TAs to have fewer manual tasks.

This research expects to respond to students' questions with general queries, including course FAQ, assignments' requirements, and class materials with the help of Google Dialogflow that understands the intent, text classification, and entity extraction for most classes accurately. This provides a way to search for the course-related questions and receive the matching answer faster and more conveniently. The chatbot is also expected to handle unknown inquiries that would return the search result from API calls instead of no response and store resolvable questions into the database for future training.

The functionality that makes ATOB different from other chatbots is the automation to connect and accept students' requests to code repository as a contributor working on programming projects. Compared to traditional chatbots that only respond for simple Q&A, this implementation involves a more interactive approach inspired by an e-commerce chatbot that can do more than just answering FAQs.

The interactive chatbot aims to make education more encouraging for learners, especially those limited to getting more information outside of online resources that are not built for an answer that students are particularly looking for. The implementation of ATOB is similar to a tailored product that was made to aid in technical education. The technical part questions are limited to one class as well as one third-party integration. However, the experiment results in understanding users' intent met the initial expectation of this research.

9. FUTURE WORKS

Future research should be devoted to expanding the development of the chatbot to cover more courses and broaden the knowledge base of technical skills. In addition, the chatbot' current ability to handle student's context and the flow of conversation is not flexible enough to keep the flow smoothly and the capacity to hand down the actual TAs for the knowledge beyond the chatbot's domain. Thus, more data would undoubtedly improve the chatbot's performance and its ability to answer more questions with a conversation flow closer to talking to a human. Moreover, we anticipate having students utilize ATOB to evaluate students' interactions about the chatbot's sense of support. Nevertheless, our results suggest a motivating direction for chatbots for education purposes, and we envision that ATOB can be expanded to ultimately provide optimal assistance to students, TAs, and faculty.

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