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Using AI Chatbots in Education: Recent Advances Challenges and Use Case

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Abstract. Nowadays, younger generation is much more exposed to technology than previous generations used to. The recent advances in artificial intelligence (AI) and particularly natural language processing (NLP) and understanding (NLU) make it possible to reinforce and widespread the adoption of AI chatbots in education not only to help students in their administrative affairs or in academic advising but also in assisting them and monitoring their performance during their learning experience. This paper presents a review of the different methods and tools devoted to the design of chatbots with an emphasis on their use and challenges in the education field. Additionally, this paper focuses on language-related challenges and obstacles that hinder the implementation of English, Arabic, and other languages of chatbots. To show how AI chatbots benefit education, a use case is described where Hubert.ai chatbot has been used to assess students' feedback regarding a machine learning course evaluation.

Keywords: Chatbots; Conversational Agents; Artificial Intelligence; Education.

1 Introduction

Technologies have evolved over the years; what we saw ten years ago as a technological revolution is now becoming ordinary. We are currently in the era of AI, where science is behind every development that simulates human thinking. Some common scientific fields where AI is predominant include computer vision, pattern recognition, natural language processing (NLP), understanding (NLU) and generation (NLG), robotics, and planning to name just a few. Moreover, AI technologies are at the pace of creating revolutions and paradigm shifts in almost all areas such as education, healthcare, business, engineering, automotive, etc. A chatbot is an AI technology powered by natural language processing techniques to learn and understand human language. It has become one of the most important tools governments and private sectors use to provide continuous communication to users 24 hours a day. Recently, many universities and educational institutions have started to use chatbot technologies to help students in the admission process and academic advising along with the learning process. Faculty members and teachers can use chatbots to follow up with students, respond to inquiries, review students' backgrounds about subjects, and assess homework, among many other

tasks. The role of chatbots in education is clear, but their design and use by either teachers or students face many challenges and difficulties.

The contribution of this work is twofold. First and as a review, the progress in developing AI chatbots for education is described, emphasizing up-to-date algorithms used proposed for their design and the challenges related to their implementation. Second, through a use case, we show how an AI chatbot can be leveraged to collect feedback from students regarding a course, namely machine learning in our case, and analyze the results.

This paper will be structured as follows: section 2 reviews chatbots, their categories based on the design approaches, the uses of chatbots in education, and discusses challenges in languages, implementations, and education. In section 3, a use case in using chatbots in education is conducted to support this research. A discussion about the use case is provided in section 4. Finally, section 5 will conclude the overall paper.

2 Literature Review

2.1 Chatbots: Definition and Structure

Generally, chatbots simulate the interaction between humans. They are widely used in education, banking, e-commerce, and business as tools to help customer support [1]. A chatbot can be defined as a conversational tool that allows users to operate computers in a simple natural language that people can understand [2]. Another attempt to define the chatbot describes it as a programmed tool that interacts naturally with the user on a specific topic or subject. This interaction can be by voice or text [3][4].

Before getting deep into chatbot technology, it is important to understand its structure. The chatbot architecture depends on the domain specified for it, but the basic workflow remains the same. As shown in Fig. 1, a chatbot takes input (text, voice, or both) from the user. Then, the input is passed to the Natural Language Processing (NLP) component in the form of text to learn and understand the user's input. Response constructor uses different algorithms to process the pre-defined Knowledge base, presents a set of suitable responses, and then passes it to the response selector. Response selector uses machine learning and AI algorithms to choose the most appropriate response [5].

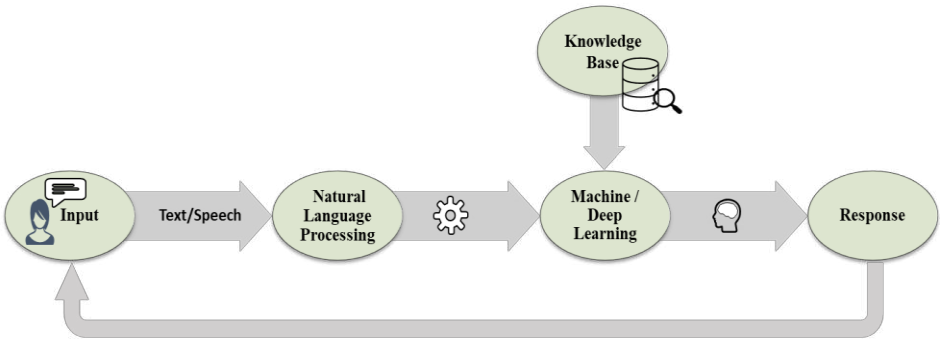

Fig. 1. General Chatbot Workflow

Chatbots can be classified into two broad categories based on their use. According to [2], chatbots can either be service chatbots or social chatbots. This classification depends on the primary function it performs and the way that its programs operate. Moreover, service oriented chatbots provide users' services in a friendly and fast way, such as online customer service, banking service, weather service, etc. On the other hand, social chatbots care more about the emotional side of customers and their satisfaction.

Other researchers classify chatbots based on the knowledge domain, service-provided, goals, and input/responses generated [6]. The knowledge domain defines the chatbot access domains if it is open or close. The open domain chatbots make conversations on general topics and give meaningful responses. In the closed domain, the chatbots answer questions from a specific domain and fail to respond to other domains' questions. On the other hand, service-based chatbots include chatbots that provide personalized, in-kind, and overlapping services between agents. Moreover, goal-based chatbots include informative, conversational, and specific task chatbots. Finally, the input method and responses generated chatbots accept input, then process it to generate output in natural language, process input based on rules, or use both techniques [6].

As can be seen on Fig. 2 below, chatbots can be classified in different ways depending on some parameters such as: functionality, knowledge domain, service provided, goals, and input method/ generated responses. Therefore, the development of a chatbot can be viewed as a combination of choices related to the aforementioned parameters.

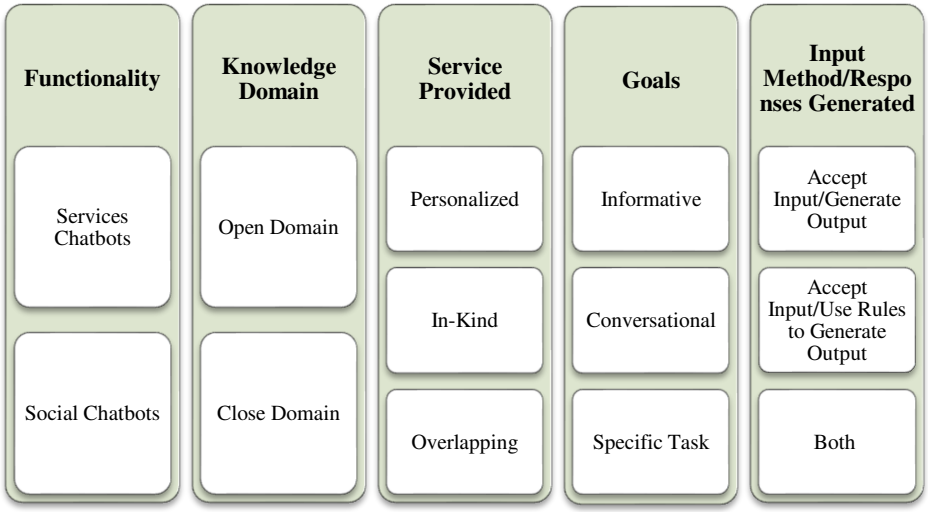

Fig. 2. Chatbots Classification

2.2 Approaches for Chatbots' Design

Chatbots can be classified based on the developing approach into three main groups: rule-based, deep learning, and ensemble approaches [5]. Table 1 presents a summary of the used approaches in the design of chatbots.

Table 1. Chatbots' Design Approaches

Approach	Definition	Pros/Cons	Example
Rule-Based Approach	It is a straightforward method with pre-defined questions and answers that match user input to a rule pattern and select a pre-defined answer from a set of responses using pattern matching algorithms. The user's question is decomposed into a set of words and then used to choose the correct output.	• Simple. • Ideal for closed-domain communications. • Not able to answer patterns that don't match pre-defined script.	ELIZA, PARRY, ALICE [7], [8], [5], [9]
Machine Learning approach	**Retrieval-Based:** select the conversation's proper responses from a database using a neural networks algorithm and re-use it to reply.	• Can returns incorrect outputs because they are totally based on retrieval of data. • Cannot handle unseen queries for which pre-defined responses do not exist.	MITSUKU, FIT-EBot [8], [10], [11], [12]
	Generative-Based generates proper responses during the conversation; it does not depend on pre-defined questions and answers. Instead, it uses neural network models or deep learning techniques to develop a dialogue with the user.	• Do not rely on pre-defined responses. • Useful for involving a person in informal open-domain conversations. • Not ideal for closed-domain communications. • Can generate mistakes. • Difficult to be trained.	CAiRE [8], [11], [13]
Ensemble approach	A hybrid approach uses rule-based, retrieval-based, or generative-based approaches to respond to user input if there is no match to any rules.	• Capable of stimulating conversation on unspecified subjects. • Improve the performances of chatbots.	AliMe, Medbot [5], [14], [15]

As it combines the advantages of the three main approaches rule-based, retrieval-based, and generative-based, the ensemble approach has been shown to significantly improve the performance of chatbots [16], [5]. Moreover, specifying the conversation domain and merge different methods with neural networks' ability make the ultimate system robust enough for real-world application [16], [5].

Each of these approaches applies one or more of the following techniques:

- **Pattern Matchers:** Used in traditional chatbots, it answers the user only if there is a pattern (lexical) matching between the user query and set of question-answer stored in its knowledge base. This kind of techniques is considered inflexible; it lacks the

intuitive ability of humans to see meaning, and the answers are given using a set of pre-defined responses [11].

- **Natural Language Processing (NLP):** Natural language processing (NLP) is a field of artificial intelligence that studies how computer systems can interpret and control natural language. Information about understanding and using human language is collected to create appropriate technologies for computer systems to manage human language and perform many tasks. Most NLP techniques are based on machine learning. They consist of Natural language understanding (NLU) which develops the task to understand text, and Natural language generation (NLG) which presents the responsibility for text generation that is commonly performed by neural networks [17].
- **Machin Learning (ML):** Algorithms that learn from conversations. They consider the whole dialog context, not just the current turn, and do not require a pre-defined response for each possible user input. However, it needs an extensive training set, which can be very difficult to provide [17].
- **Deep Learning (DL):** Chatbots built using artificial neural networks learn everything from data and conversations with humans. It is trained to develop its own opinion on the text and be more effective by using more and more data. Retrieval-based and generative-based are the two major types of bots created using deep learning [5].
- **Reinforcement Learning (RL):** is a machine learning framework for learning and continuously improving policies by a computer algorithm through interacting with its environment. Reinforcement learning algorithms that incorporate deep learning (implemented as a neural network) are known as deep reinforcement learning (DRL) [18][19].

In recent years, the chatbot's technologies powered by combining more than one technique in the field of AI and NLP to accurately mimic the real-life conversations between humans and overcome the limitations of the traditional chatbot.

2.3 The Role of Chatbots in Education

Many researchers studied and evaluated the benefits of using chatbots in educational institutions. They present how the educational agent participates directly in the online discussions, assists the teachers in following the chat discussion, uses natural language processing (NLP) to understand and find the main points in the student discussion, and applies sentiment analysis of the chat responses [20].

A study on Facebook messenger educational chatbots focuses on topics and language used in conversation. The development platform showed that (89%) of the chatbots under investigation use English as their primary communication language. Moreover, about (46%) of chatbots cannot be used to discuss any technical issues or simulate human conversation [3]. Most of the chatbots' topics were learning languages, economic topics, simulate conversation with historical figures, and learning computer science concepts [1].

A chatbot offers an interactive way of learning, similar to the one-to-one interaction between student and teacher. The chatbot provides educational features, including solving individual problems (e.g., current student, parents, graduated). The chatbot has

become more important from another perspective, as it saves costs by replacing human assistants and increasing user satisfaction because of the speed response and availability 24 hours. From the students' perspective, and by using the chatbot, students can expand their knowledge, exchange ideas, reduce learning loads, and feel more connected, especially the first-year students[21][22]. Chatbots become suitable for teaching individuals at different levels and abilities because it increases their confidence. From the teachers' perspective, they can use the chatbot to send announcements to students, help correct homework (e.g., identify spelling and grammar mistakes), and track student progress [22].

Moreover, chatbots are used in education to handle frequently asked questions, administrative tasks, student mentoring, motivation, student learning assessments, simulations, training, and providing feedback. For example, in a real case in Cardenal Herrera University, a chatbot acts as a personal assistant to monitor students, predict their behavior, answer administrative questions, and give advice [6].

The most important characteristic of a chatbot is its availability for learners on their mobile devices. It provides an educational method suitable for modern students in terms of speed and convenience, where communication is possible through mobile at any time and place. It also provides immediate feedback and follow-up to students based on their understanding and repetition of information according to their needs. Shy students interact greatly through chatbots, especially learning new languages; it helps them speak fluently and comfortably without judgment because they are sure they are not talking to real people [23].

The educational content is usually huge, and thus students are less interested in starting to learn due to a large number of scientific materials. For example, the database systems course contains many exercises, explanations, examples, and tasks that are often considered difficult for students. However, it is possible to motivate students to start solving them by gradually presenting these tasks, which helps the student search quickly through a chatbot teacher, which can be easily accessed in several ways, including websites or social media [24].

In some higher education institutions in India, an experimental research has been conducted to explore the factors that affect chatbot technology adoption. A sample of 47 students and a series of 10 questions have been used to conduct the study. One of the questions in the study measures the response time by the communication channels, around 61% of the students choose chatbot as the quickest communication tool, online chat take second place with 19%, phone calls 8.7%, 6.5% for face-to-face communication, social media and e-mail get 2.2% for each [6].

Another experiment has been conducted on a group of undergraduate students in the university in Hong Kong for the course principles of networks while using a chatbot named Infobot for 15 minutes. Infobot answers questions related to the educational material, students' grades, academic schedule, and the teacher's office hours. The experiment uses a questionnaire to measures students' satisfaction with the information provided by this chatbot; this information has been previously entered into the database by the teacher. The vast majority of students, nearly 60%, agreed on this chatbot's efficiency and how it helped them get the required information faster and relieve pressure on the teacher by facilitating communication and accelerate learning [25].

In the Faculty of Information Technology of Ho Chi Minh City University of Science (FIT-HCMUS), the increasing demand for learning has put a lot of pressure on this higher education institution. The clear proof of this is that the number of students per teacher increases, which means that each teacher's support for each student has decreased dramatically. This is one of the main reasons that lead to ineffective learning and a high dropout rate. Although many solutions are proposed to solve this problem, most of them cannot be successfully implemented due to financial and organizational difficulties. Scholars and administrators have begun to introduce chatbots into the education sector to face these challenges. 2018 was the year when chatbots were popular in education. One of the chatbot's most significant advantages is its ability to support students individually and with interest. This is especially useful in large-scale learning environments like universities or open online courses (MOOCs) [12].

In this research, we concentrate on the use of chatbots in education institutions. Table 2 shows some education chatbots.

Table 2. Educational Chatbots

Chatbot Name	Purpose	Notes
FIT-EBot [12]	•Provide administrative and learning support to students at the Faculty of Information Technology of Ho Chi Minh City University of Science, Vietnam (FIT-HCMUS) on behalf of the academic and administrative staff.	•Users can interact directly with the FIT-EBot through their Facebook pages. •The data collected from the FIT-HCMUS will better support students compared to other general chatbots.
LABEEB: (means Wise-man in Arabic) [26]	•Conversational agents respond to student inquiries in specific courses, objectives, learning outcomes, and academic rules and regulations.	•Labeeb successfully receives inquiries in either text (English or Arabic) or speech format (English).
Percy [27]	•Percy is a computer science teaching assistant chatbot that teaches CS 221 course at Stanford University.	•If a similar question has already been asked, the chatbot is generally able to retrieve it. If no similar question has been asked, the bot can recognize that and respond," I don't know". •Percy performs well on policy questions.
Python-Bot [28]	•Chatbot for teaching Python programming.	•The design of Python-Bot was user-friendly, making it easy for students to use.

There are numerous public and private universities in Saudi Arabia to teach the growing number of students. Therefore, an increase in the number of students means an increase in the number of inquiries 24 hours a day. This requires a sufficient number of employees to achieve the required level of service quality. After investigating the websites of Saudi universities, the results indicated that chatbots are not fully utilized [29].

2.4 Challenges

Many challenges face the effective use of chatbots; this section covers some of them in terms of languages, implementations, and education.

Language Challenges:
. Chatbots are developed for many languages such as English, Arabic, French, etc. However, each language has its own sentence structure, punctuation rules, and the use of spaces, which is a barrier for current chatbots to deal with [11][30]. For English chatbots, the authors [11] mentioned several points that affect the efficiency of chatbot conversations; the most important ones include the inability to recognize grammatical errors and similar meanings questions. Moreover, information retrieval from a database is not realistic; two questions may look different in terms of words but have the same meaning, so similarity measures should be used to eliminate differences [11][31].

On the other hand, the Arabic language chatbots have many linguistic complexities, it consists of several variants that are quite different from each other: Modern Standard Arabic, the official written/read language, and several dialects. Moreover, Arabic writers make very common mistakes in spelling some problematic letters, such as Alf Hamza and Ta Marbouta. Morphological richness Arabic words are influenced by a large number of features such as gender and numbers. Also, verbs, adjectives, and pronouns are all gender-specific, requiring the chatbot to have two different responses systems - one for male users and one for female users. As in other languages, Arabic has its own set of unique dialogue expressions, for example, while the English greeting expression “good morning” gets the answer “good morning”, the Arabic equivalent greeting “صباح الخير” “Morning of Goodness” gets the answer “صباح النور” “Morning of Light” [32][33][34]. A collaboration between linguists and computer scientists is required to overcome these challenges.

Implementation Challenges:
. Users sometimes tend to initiate domain queries during a conversation with a chatbot and then suddenly move to another domain; this may lead to significantly weak accuracy [10][11]. Moreover, the performance of a chatbot is dependent on the size and accuracy of the databases, so the higher the database size, the better the performance. The semantically similar questions unidentified by the system would be real problems unless the developer included the semantically equivalent words in the terminology section [10][11][31]. Moreover, lack of chatbot personality can also push users away from the dialog, this risk can be reduced by giving the chatbot a name and an avatar. Gender and time recognition are real issues; the chatbot has no sense of time and often replies with the same “Have a good day” or “Good morning”, regardless of the time of day [10]. In the research [35], some issues regarding the Question Answering system (retrieval-base) are found. The research mentioned that the system answer questions related to only a particular domain. The user must follow a specific format when asking questions. They suggest using a sequence-to-sequence model (generative-base) to overcome this issue.

Educational Challenges:
. In educational institutions, many challenges are facing the implementation of chatbots. Students feel that they are not interested in speaking with chatbots because the conversations have become monotonous with the long period of use. Therefore, more attention needs to be paid to improving chatbots to be more like chat agents [31]. Furthermore, the chatbot does not understand students' feelings and their satisfaction or anger. Also, it does not give advice or ask questions [11].

3 Use Case

Hubert is an artificial intelligence chatbot that replaces the traditional way of filling surveys by chatting with users. Currently, Hubert is aimed towards three different domains: customer experience, human resources, and education. Depending on the choice, the survey is set up using specific questions about that domain. Hubert consists of two main parts: the chatbot itself and the dashboard. In the dashboard, the user chooses the domain and then customizes the pre-defined questions. Finally, it gives the user options to start talking with the chatbot (copy the link or e-mail the participants). When the participant clicks on the chatbot link, a window with a typical chat layout opens, and Hubert starts the conversation [35].

To get a closer look at the importance of chatbots in education, A practical experiment was performed on Hubert chatbot to get student feedback about a machine learning course. Since it was the middle of the semester, while applying the experiment, we chose the informal course evaluation – during the semester version of Hubert.

This paper focuses on using AI in education, and Hubert provides a great tool to serve this goal. The education domain of the Hubert chatbot allows teachers to get direct feedback from the student. The students' feedback allows the teachers to identify gaps in their teaching efforts and do better. The Huber chatbot makes inquiries like how the course can be improved, what to change, what is functioning admirably, and what is not. The chatbot investigates the conversations, does some analysis, and then sends it to the instructors [36].

Feedback Hubert website contains several models that provide feedback based on the need of the teacher: stop/start/continue evaluation for mid-term feedback, students' self-reflection – beginning/middle/end of the semester, informal course evaluation – during the semester/at the end of the semester and customized template for the Edubots project.

All participants are postgraduate students (26 female students) from Princess Nourah bint Abdulrahman University in Riyadh, Saudi Arabia. During the lecture, the instructor shared a link with the student. The link opens the Hubert chatbot webpage directly and asks the students if they are ready to start (see Fig. 3).

The Hubert chatbot starts asking students about their opening on the course and what the instructor should do and stop doing. Moreover, Huber encourages students to give some solutions and not participate only with yes and no. If a student does not provide a real answer, Hubert tries to encourage him by asking a follow-up question (see Fig. 4).

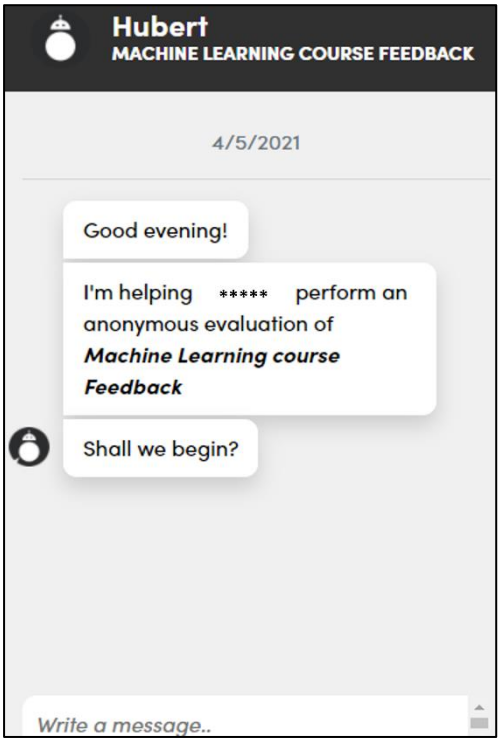

Fig. 3. The start of the conversation

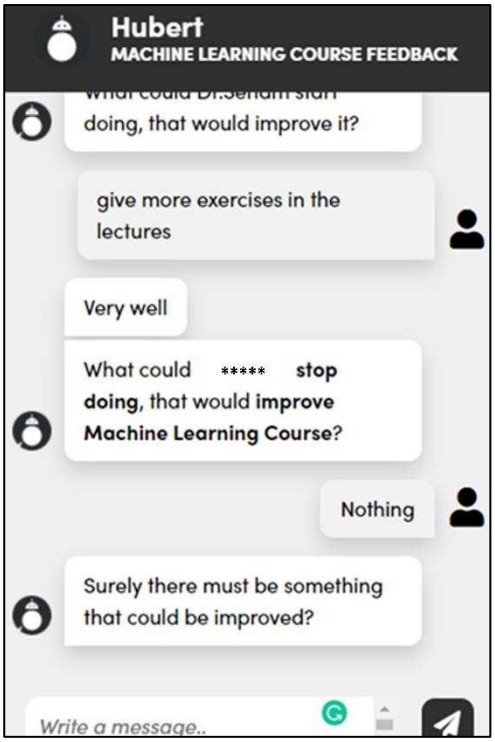

Fig. 4. Follow-up question to encourage student

At the end, Hubert asks the students to evaluate the experience of talking to it and then terminates the conversation (see Fig. 5).

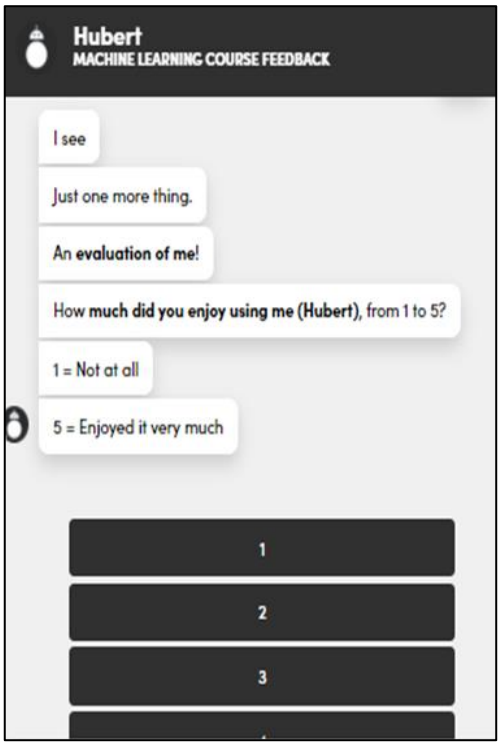

Fig. 5. Evaluating Hubert

On the other hand, the instructor can view all the transcripts with the students, and an analysis of them in the dashboard. The dashboard provides the most discussed topic and sentiment analysis for each student's answer, if positive, negative, or neutral. The instructor can change the sentiment analysis if he sees it incorrect.

The feedback chatbot asks seven main questions as follows:

- What is working well with _____ and should **continue** in the same way?
- What is working well with _____ and should **continue** in the same way?
- What could _____ **stop doing**, that would **improve** _____?
- What class activities or **assignments** help you **learn the most** so far?
- What is your **overall experience** of _____ so far?
- Are there any **other points** you would like to comment on?
- How **much did you enjoy using me (Hubert)**, from 1 to 5? [37]

4 Discussion and Results

Our experiment got 100% responses from the class students; they were excited to talk to the chatbots. Using the dashboard makes it easy to know the strengths and weaknesses of the course and clarify the most important points in students' conversations

with the chatbot to develop the course. If the students interact with negative responses such as “nothing” and “no”, they are encouraged by the chatbot to participate more by asking a follow-up question, “Surely there must be something that could be improved?”.

In our experiment, around 42% of the students responded negatively at first, but the percentage reduced to about 7% after motivating them with another question. At the end of the experiment, students were asked to rate their talking experience with the chatbot. Hubert received a 3.6 out of 5, with 19 students rating 5, 4 students rating 4, and 3 students rating 3 (see Fig. 6).

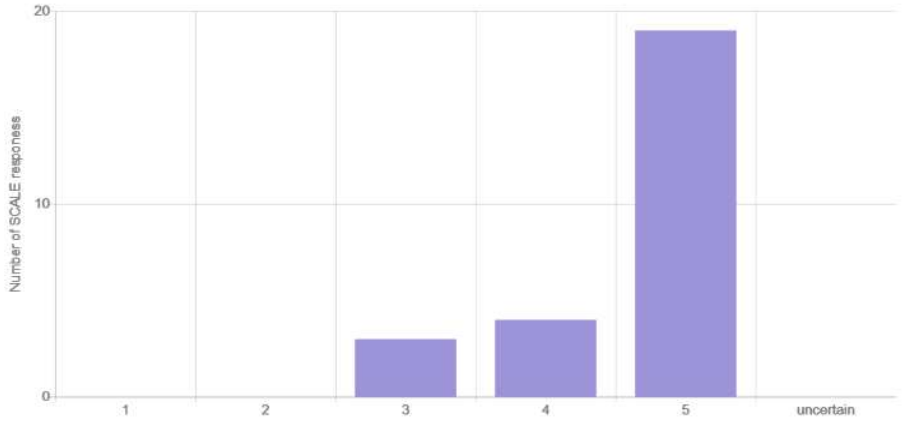

Fig. 6. Hubert evaluation

As a disadvantage, the dashboard needs more improvement as a disadvantage since it may give false results because it counts the incomplete answers. For example, if the student answers some questions, quits the conversation, and then comes back later and answers the same questions, it will count them as two different responses. Moreover, It may also give misleading results because it measures the frequency of words regardless of their meaning. Furthermore, teachers have no control over the responses that appear in the dashboard; they can not hide or delete any of them. For that reason, the summaries in the dashboard are not very helpful to the teachers.

5 Conclusion

This study explores the existing chatbots’ domain of use, language characteristics, and design approaches. The study also focuses on the most important practices of using educational AI chatbots as a parallel educational tool, virtual teaching assistant, trainer to practice English as a second language, and virtual agent to get student feedback. In addition to their ability to serve some issues related to registration and administrative problems for students. Educational chatbots are still in their early stages, and many researchers have used recent AI techniques such as in deep learning and reinforcement

learning to improve the performance of chatbots. However, there are still major technical, linguistic, and psychological challenges. Recent researches suggested combining more than one technique in the field of AI and NLP to overcome the challenges of the existing chatbots.

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