

Chatbot Development using APIs and Integration into the MOOC

MZWRI Kovan, TURCSÁNYI-SZABÓ Márta

Abstract. In recent years, chatbot technologies have evolved into modern information and communication technology applications that perform many virtual tasks, including learning. One of the challenges in improving the chatbot is the insufficient knowledge base of chatbots, including education-oriented conversational agents, the challenges in connecting the chatbot with course content on Massive Open Online Course (MOOC) platforms. In this study, a chatbot was developed to answer questions using publicly available technologies, specifically Application Program Interfaces (APIs) that promise convenient user accessibility via APIs, such as the Facebook Messenger platform along with wit.ai API, Canvas MOOC API, and Wikipedia API.

API technologies were used to connect the chatbot to selected course content on the MOOC platform as well as to large knowledge bases such as Wikipedia to expand the knowledge base of the Conversational Agent. The course selected for the chatbot integration was on general informatics topics. Most course participants interacted with the chatbot via the Facebook Messenger platform using their handheld devices. Thus, integrating the chatbot into a widely used platform such as Facebook Messenger is a convenient and effective way for reaching learners. The API technology enabled an efficient connection between the chatbot and third-party apps, including the Messenger app, wit.ai, Canvas MOOC, and Wikipedia. This was due to the variety, richness, manipulation capabilities, and format of data that an API can transfer. In addition, the Wikipedia API seemed to be a vast source of information for expanding the chatbot's knowledge base. Not all of the queries posed to the chatbot were part of the course content. Some participants questioned the personality of the chatbot and were curious about the persona of the conversational agent. This suggests that a chatbot that has been endowed with some personality traits is stimulating and more likely to be accepted by learners.

Keywords: Chatbot, Conversational Agents, Pedagogical Agents, Intelligent Agents, API, Canvas, MOOC

1. Introduction

Technology has changed the way people communicate and interact. One of the rapidly emerging innovations is the development of chatbots or conversational agents. In the past year's chatbot technologies have proven to be effective modern Information Communication Technology (ICT) applications that perform many different virtual tasks [1]. Chatbots are computer agents that communicate naturally with humans using text and speech. By applying Natural Language Processing chatbot can communicate and assist the user to perform some tasks in a specific domain [2].

Chatbot applications have a long history of development. The world's first chatbot named Eliza [3, 32] was developed by Joseph Weizenbaum in 1956. It simulated a psychotherapist and aimed to explore natural language and communication between humans and machines. Since then, the use of chatbots has increased greatly and there are estimates that their use will increase even more in the coming years [5]. With the advent of artificial intelligence and the development of natural language techniques, the use of chatbots has expanded to a variety of fields, including medicine [6] customer service [7, 36] banking [35] personal assistance through smart speakers [8], and educational applications [9]. In general, chatbots can be divided into task-oriented and open-domain chatbots [10]. Task-oriented chatbots are designed to perform a specific task such ordering food or booking tickets. Open-domain chatbots can carry on a conversation on a variety of topics, provide entertainment, and socialize. Open-domain agents are still in their early stages; task-oriented chatbots on the other hand, currently have a large market share [11].

In recent decades, Information and Communication Technology has significantly changed the higher education environment and the Smart Learning Environments (SLE) approach has emerged, which uses innovative technologies and artificial intelligence to enable greater flexibility, personalization, engagement, and motivation of learners [12].

The use of these technologies has become crucial as the high demand for education has recently put a lot of pressure on higher education institutions. Clear evidence of this is that the number of students per teacher is increasing [13]. This means that the support of each teacher for each student is decreasing significantly [14]. This is one of the main reasons for ineffective learning and a high dropout rate [15, 16]. Academics and managers have started offering chatbots to address these daunting challenges in the education sector. Chatbots promise to solve a variety of problems in education today [27]. One of the biggest advantages of chatbots is that they can provide students with personalized and intensive tutoring [17], which is especially useful in large learning environments at universities or in Massive Open Online Courses. The fundamental issue with chatbots is limited communication due to a lack of vocabulary and information that is incomplete or incorrect [18, 19, 20]. Due to this problem, chatbots have a low penetration rate and their use is limited to the simple dyadic conversation [21, 22, 23, 4]. Therefore, future research should focus on expanding the knowledge base and turning the chatbot into an open educational resource [24, 25]. Most studies on chatbots in learning have been conducted in controlled experimental settings [26, 27, 28]. We need more research that focuses on the integration and use of chatbots 'in the wild', i.e. in the original environment of Massive Open Online Courses.

Our research question is to investigate the potential of using current online communication technologies to develop a chatbot and connect it, on the one hand, to massive knowledge centers that enable real-time communication and data transfer between chatbot and these platforms, to expand the knowledge base of the conversational agent, and on the other hand, to integrate the chatbot in real-time with course content on a MOOC platform so that the chatbot can respond to course-related questions from users using these communication methods and explore the possibility of deploying the chatbot on these platforms.

With respect to the research questions in this study, we will use publicly available technologies to develop a chatbot utilize application program interfaces (APIs) to connect the developed chatbot to course content on the MOOC platform as well as to large knowledge bases such as Wikipedia to expand the knowledge base of the conversational agent. Web APIs, also known as representational state transfer (RESTful) services [29] when they conform to the architectural principles of REST [30], are characterized by their relative simplicity and their natural fit for the Web. Based on this simple technology, many websites such as Facebook, Google, Wikipedia, and Twitter offer user-friendly public APIs that provide easy access to some of the resources they offer and allow third parties to combine and reuse heterogeneous data from different services. We will apply this technology to develop an online solution that connects various components of the chatbot and expands its knowledge base, where information is pushed and responses are received in a real-time.

2. Materials and Methods

2.1. Chatbot Development

There are several platforms for developing chatbots, most of which are commercial and require payment for resources depending on the package used. One of these platforms is Chatfuel. From a developer perspective, the Chatfuel service is the most commonly used platform for chatbot development [32]. When developing the chatbot, our priority was to use publicly available technologies that provide modern development, integration and communication methods.

The Facebook Messenger app was used as the initial and client-side component of the chatbot. This platform offers several free API services that can be used indefinitely. Only verification of legal use of the API services is required. Recent statistics show how heavily Facebook Messenger is used and adopted by social media and mobile device users. Every month, more than 1.3 billion people use Facebook Messenger [31] and the Facebook Messenger mobile application is the third most used app in the world, used by 68 percent of users [32]. In addition, Facebook Messenger platforms support rich media, such as images, animated Graphics Interchange Format (GIFs), and videos. Therefore, we assume that this platform can provide a convenient input or messaging channel between course participants.

The wit.ai API was used as the Natural Language Processing (NLP) engine for the chatbot. Wit.ai is an open and extensible NLP engine for developers that was acquired by Facebook. It is a free software-as-a-service (SaaS) platform that provides a simple user interface and fast-learning APIs to understand human communication in every interaction and helps decompose the complex message, whether speech or text, into structured data (intent and entities). Wit.ai provides a Graphical User Interface (GUI) that facilitates the creation of efficient and powerful text or speech-based conversational bots that humans can interact with.

To connect the chatbot to the selected course content available on the Eotvos Loránd University MOOC platform, the Canvas API was used with multiple endpoints to retrieve specific information about the course in each case. The Canvas MOOC and Learning Management System (LMS) provides a REST API for accessing and modifying data outside of the main application using code and scripts. This allows data to be easily transferred between these platforms as well as external applications. An access token is required to access the Canvas API and the API authentication process is done through OAuth2. Several Canvas APIs were used to retrieve various information about the course and its content, such as the Courses API, which was used to answer questions such as course start and end dates, course name, course modules, course announcements, and participants, etc. This information was dynamically generated from the course attributes on Canvas MOOC and sent to the chatbot server via the API to answer users' questions.

The knowledge base of our chatbot was extended by using the Wikipedia API with its various endpoints. For example, the Wikipedia search API to search for the forwarded term, to check whether it occurs in Wikipedia or not, and to find the most related terms. Also, the Wikipedia summary API generated a summary and an image of the found term, if one was available.

The answer generation component worked in such a way that if the answer to the user query was not found in the course content, the questions were sent in structured data to the Wikipedia knowledge center via the API. In general, Wikipedia API answers were structured in the form of a summary of the term with an image, if available, and four randomly selected related terms for which the user could also submit a query.

Figure (1) illustrates the general structure of the chatbot, which consists of different components. In each component, different technology has been used. The connection between all the components is made through API technologies including Messenger app API, wit.ai API, Canvas MOOC API, and Wikipedia API. The user interface of the chatbot is managed by the Facebook Messenger app. From this component, the user begins interacting with the chatbot, either through the Facebook Messenger platform or through the chatbot plugin that makes the chatbot accessible on the selected course page of the MOOC platform. A Page Access Token and an App Secure Token are used to connect the Facebook Messenger app to the chatbot webhook (server). The chatbot webhook or server was implemented in NodeJS and JavaScript programming technologies. This component was responsible for forwarding the user messages to all other components and sending the response message to the Facebook Messenger app. From the chatbot server, the received user message was first sent to wit.ai, the NLP component of the app, to generate structured information from the user messages by detecting the intent and entity. wit.ai sent the structured information back to the server via the API. This data was used to generate the answer message by first sending it to the course content on the MOOC platform via the Canvas API and database to search for the answer. The process of searching for answers is based on structured information received from the wit.ai NLP unit via the API. Once a relevant answer is found, the server sends it to the user via the Facebook Messenger interface. In case no matching answer could be found in the course content and database, the data was sent to the Wikipedia knowledge center to search for a matching answer. The chatbot responded with a default message generated by the chatbot's server or the webhook if there was no matching answer based on the structured data entity.

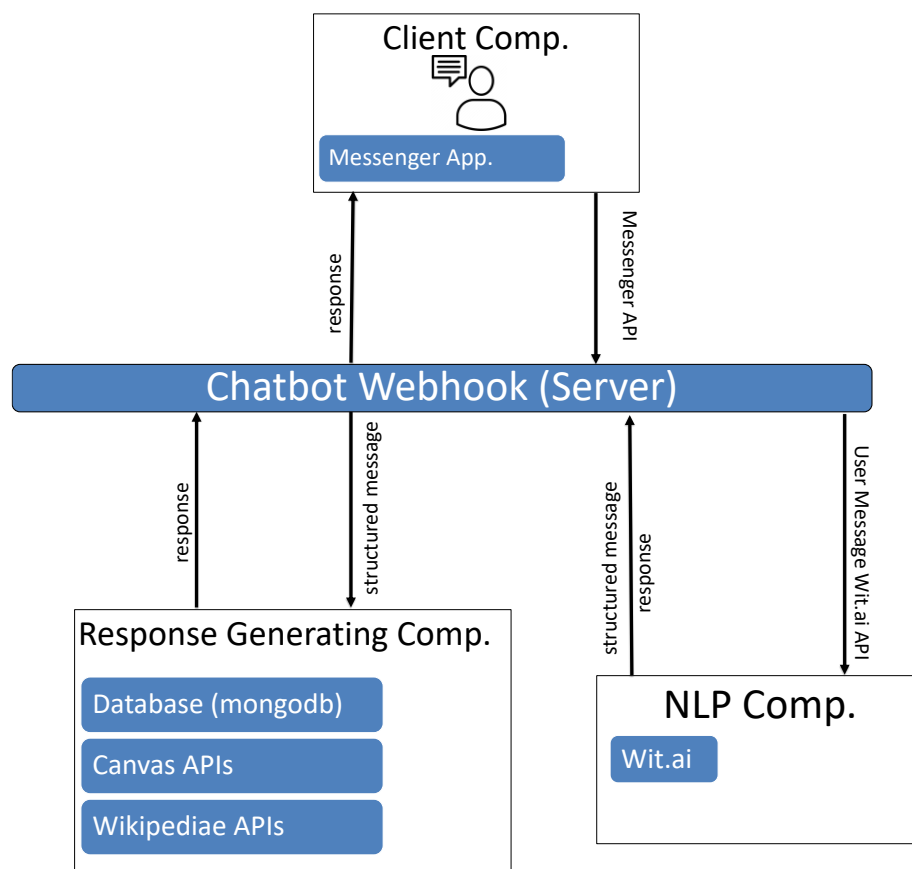


Figure 1: General Structure of the Chatbot

2.2. Course Selection and Data Training

After developing the chatbot using publicly available technologies and APIs, the next step was to select an appropriate course and integrate the chatbot into that course. The course we chose for this purpose was the popular Experiential Informatics course on the Canvas MOOC platform of Eötvös Loránd University, which was open to the general public in the Hungarian language from June 10 to August 31 in the summer of 2021. It enables practicing teachers to increase their motivation with fun Information Communications Technologies tools, students to experience the diversity of computer science as a profession, parents to discover apps that facilitate learning, and anyone interested in the wonders of informatics to learn in a community.

From the selected course content, 316 question-answer pairs were generated by going through each model of the course and identifying the possible questions students might ask. This dataset was used to train wit.ai, the NLP component of the chatbot, with the course content. Based on the questions generated in the dataset, different intent categories were created in wit.ai, such as *get_course_info*, *get_defention*, *get_module_info*, etc. For each question, the intent and an entity were detected by wit.ai. The most important part of the structural information created by wit.ai was the resolved value of the identified entity in the question since the answer generated by other components depends on this value.

2.3. Data Analysis

For data analysis, we technically monitored the app log to analyze user messages to the chatbot and the conversational agent's response to user messages. To incorporate user feedback regarding the chatbot response to their message, each chatbot response was assigned a question asking the user if they were satisfied with the chatbot response to that particular question. The user could choose the option YES or NO.

The Messenger Analytic App and wit.ai Insights were used to analyze the interface through which the user interacts with the chatbot and the user's satisfaction with the chatbot response. In addition, these analytics tools were used to investigate the source of the chatbot response, e.g., to determine whether it came from the Canvas MOOC APIs used to connect the chatbot to the selected course content, or whether the response came from the Wikipedia APIs.

Due to the outage of the Facebook social network and its affiliate apps on October 4, 2021, and the discontinuation of the Facebook Analytics app process, [37] there were difficulties in efficiently retrieving the expected data from Facebook Messenger Analytics.

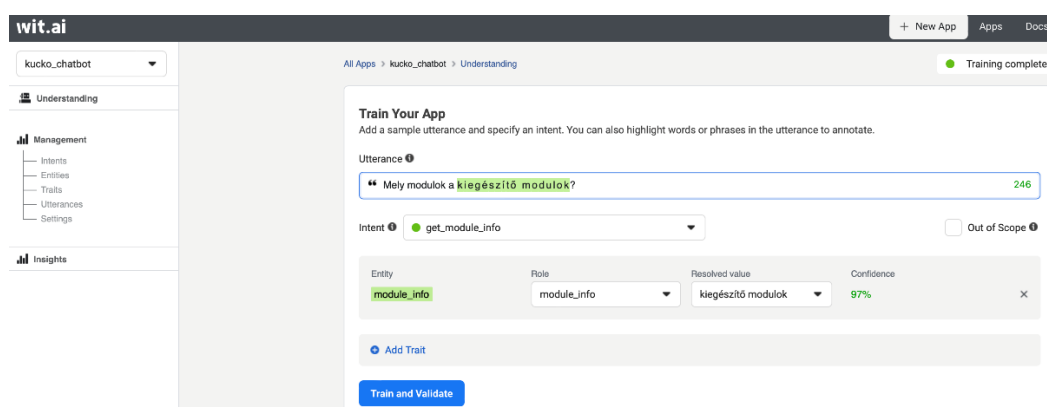


Figure 2a: Wit.ai Data Training Examples

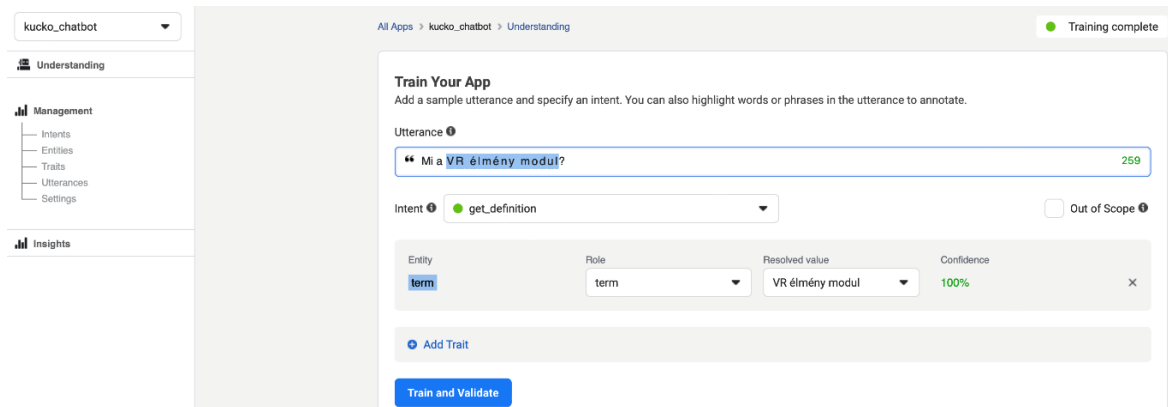


Figure 2b: Wit.ai Data Training Examples

3. Results

The result of the data collected and analyzed from the time the course was running shows that there were a total of 214 individual interactions and engagements between different course participants and conversational agents. Of these, 149 used the Facebook Messenger app to initiate an interaction and conversation, representing 69% of the total number of interactions. On the other hand, 65 other interactions, which accounted for 31% of all interactions, were initiated through the chatbot plugin, either through the course page on the Canvas MOOC platform or through the chatbot plugin on the website developed specifically for the course. This indicates that most students engaged with the chatbot through the Facebook Messenger platform using their handy devices.

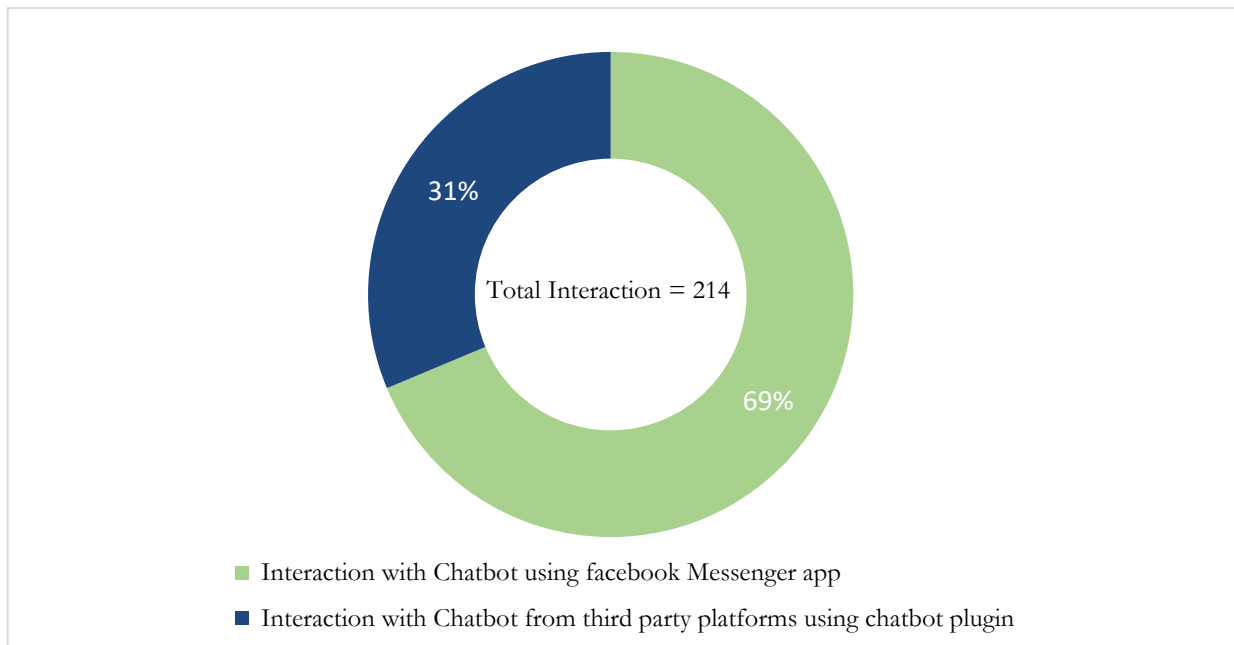


Figure 3: User Interaction with the Chatbot

The above number of interactions yielded a total of 418 unique utterances, although this number could undoubtedly be higher if we counted duplicate utterances, as the same utterance or question could be asked by different users. Participants identified 286 conversational agent responses to these utterances as correct responses, representing 68% of the total utterances. The remaining chatbot responses were either identified as inaccurate or not reported back by the participant.

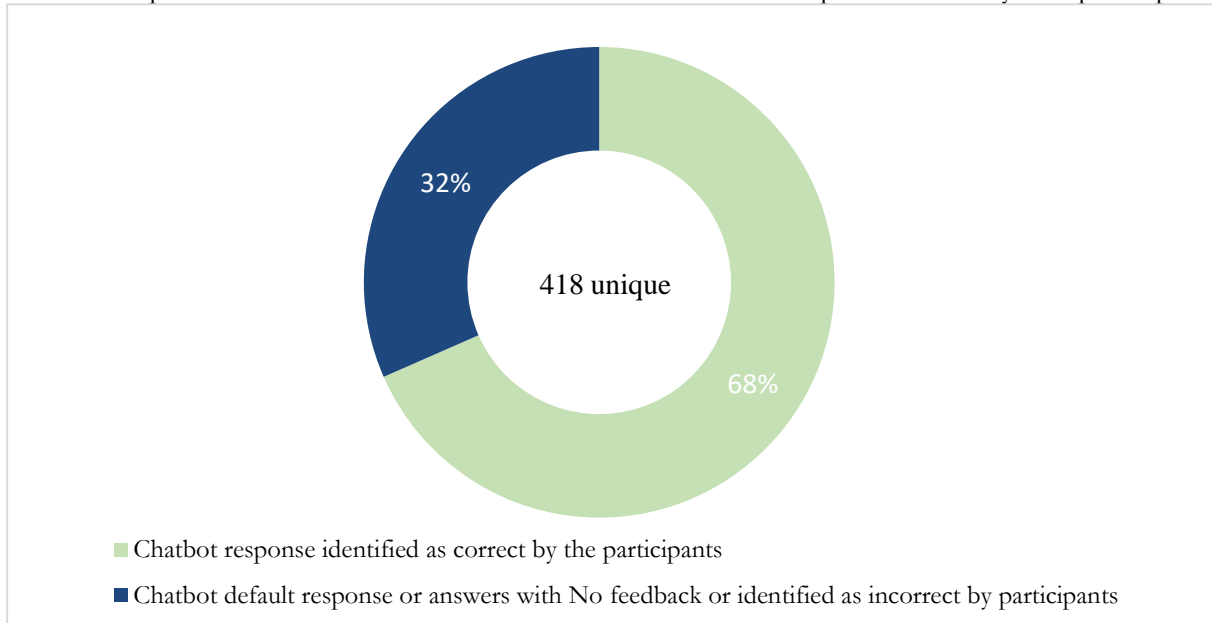


Figure 4: Users Feedback to the Chatbot Responses

Regarding the source of correct chatbot answers, 60% of all correct answers given by chatbots to participants' questions came from Wikipedia APIs and 40% from Canvas APIs used to access course materials. API technology appeared to be a reliable means of developing a chatbot and connecting it to the course content on MOOC platforms such as Canvas and real-time information centers to expand the knowledge base of this tool.

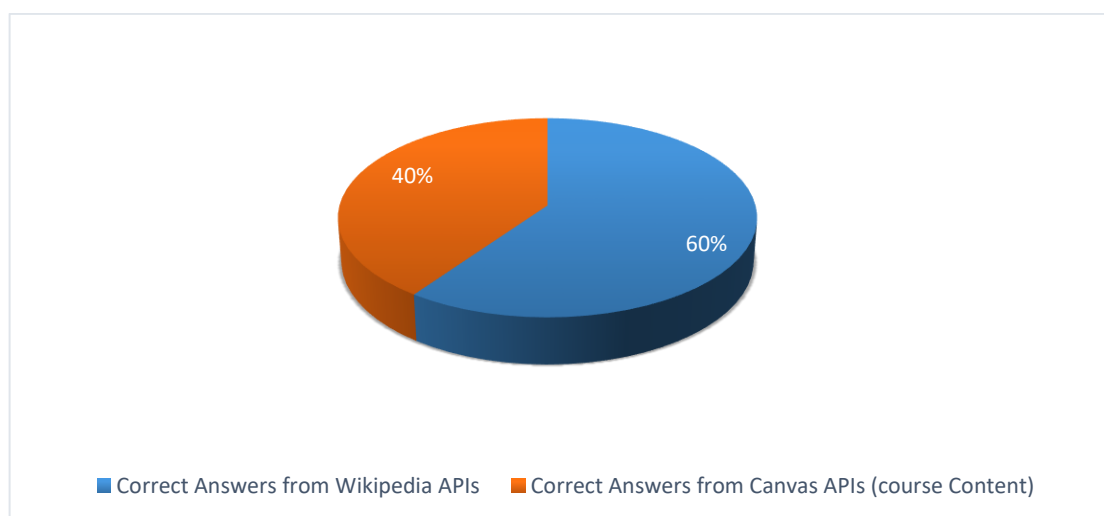


Figure 5: Source of Chatbot Correct Answer By APIs

3.1 User Satisfaction

In terms of the type of questions asked by the participants, the data analysis shows that participants did not always ask course-related or general information questions, but also questions about the personality of the chatbot. In other words, students expect the chatbot to be a socializing tool in which they can communicate with and satisfy their social needs, not just an educational agent. This is consistent with other research suggesting that chatbots' ability to convey empathic emotions, support life skills, and self-disclosure will lead chatbots to be a promising source of everyday companionship, rather than being perceived as cold, socially awkward, and untrustworthy [33, 34, 28].

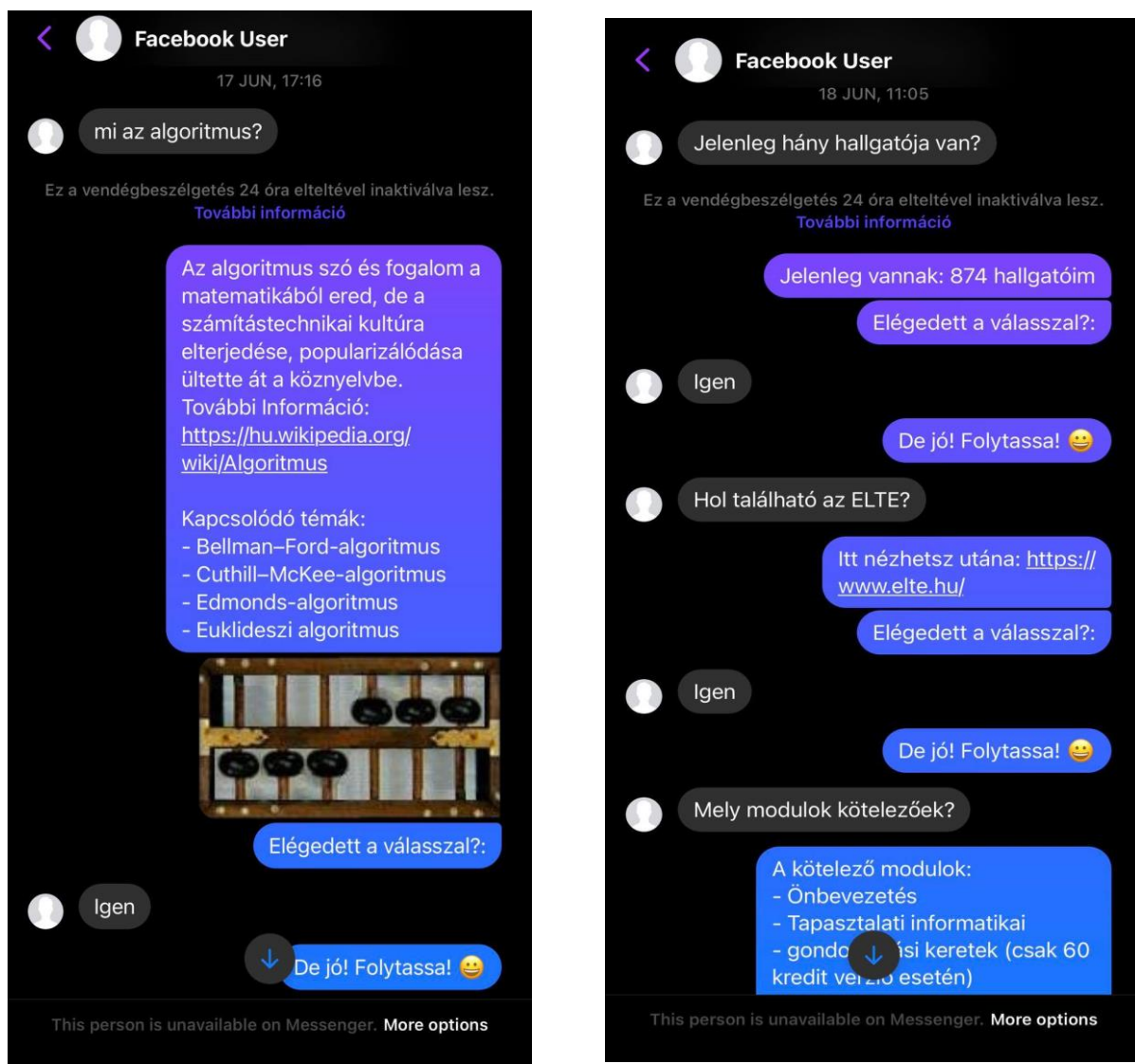


Figure 6a: Examples of User-Chatbot Messaging

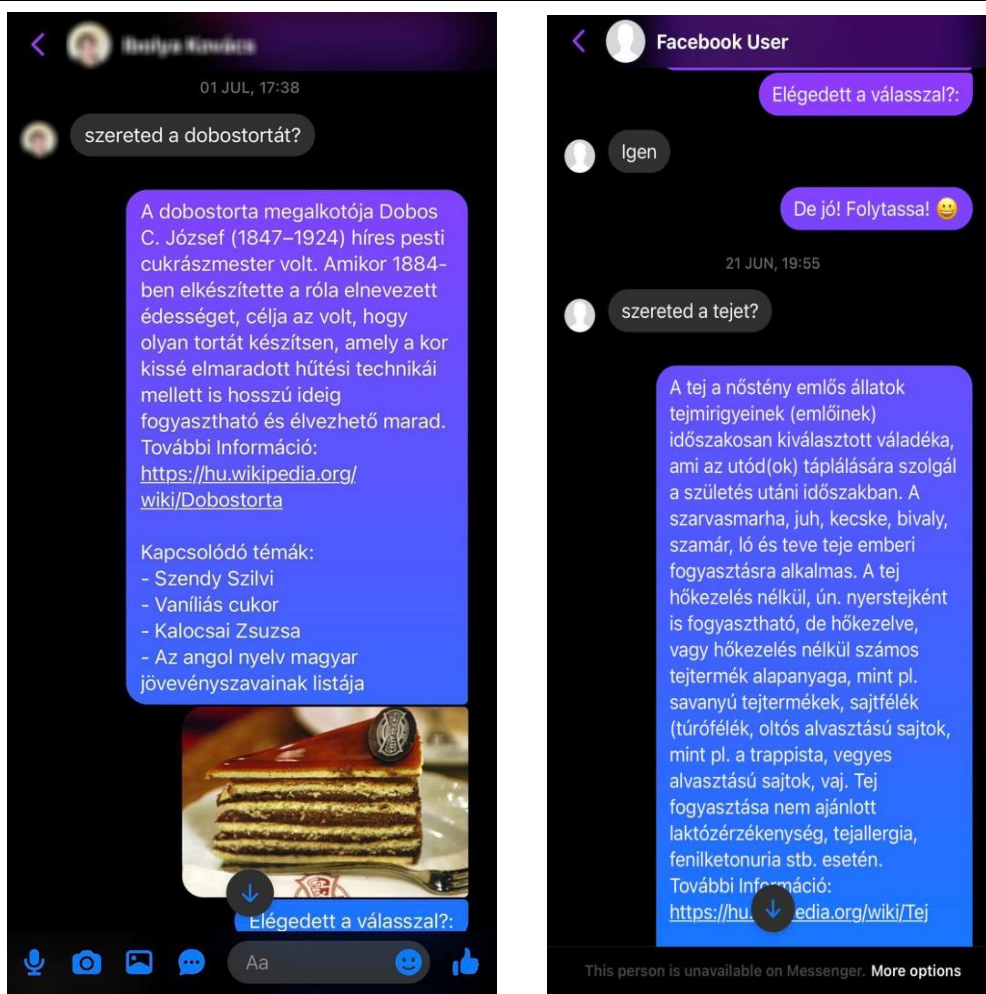


Figure 6b: Examples of User-Chatbot Messaging

4. Conclusion

The availability of sophisticated methods to access chatbots is essential for the constant and convenient use of chatbot technology. In this study, we used the Facebook Messenger platform to integrate the chatbot through an API, which proved to be a well-accepted and user-friendly platform for interacting and messaging with the chatbot. It was observed that most students engaged with the chatbot through Facebook Messenger, utilizing their portable devices, emphasizing the convenience of this platform.

The API technologies enabled robust connectivity and data exchange between the chatbot and course content on the Canvas MOOC platform on the one hand, and third-party applications such as Wikipedia Knowledge Center on the other. This was due to the variety, richness, manipulation capabilities, and format of the data that an API can transfer in real-time. However, the effectiveness of the chatbot's content delivery is contingent on the structure and design of the course content on the Canvas MOOC platform. The type and amount of course content that the chatbot receives depends on the nature of the data, whether structured or unstructured, and the design of the course materials. Moreover, the integration of the Wikipedia API provided a vast repository of information that was beneficial in expanding the chatbot's knowledge base.

The study disclosed that the participants demonstrated a tendency to inquire not solely about the course, but also regarding the personality traits of the chatbot. This finding implies that in the future design of chatbots, personality characteristics of these intelligent conversational agents ought to be taken into consideration. This suggests that chatbots should be designed to provide more than just factual responses but also engage users in a more personalized and human-like manner.

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