An Overview of the use of chatbots in Medical and Healthcare Education

Fotos Frangoudes [1[0000-0002-2543-8194]], Marios Hadjiaros [1[0000-0003-1918-7330]], Eirini C. Schiza [1[0000-0002-3593-6605]], Maria Matsangidou [1[0000-0003-3804-5565]] Olia Tsivitanidou [1 [0000-0002-9985-0333]] and Kleanthis Neokleous [1]

[1] CYENS Centre of Excellence, Nicosia, Cyprus

f.frangoudes@cyens.org.cy, M.Hadjiaros@cyens.org.cy, e.schizas@cyens.org.cy, m.matsangidou@cyens.org.cy o.tsivitanidou@cyens.org.cy, K.Neokleous@cyens.org.cy

Abstract. Chatbots are becoming a trend in many fields such as medical, service industry and more recently in education. Especially in healthcare education, there is a growing interest in integrating chatbots in the learning and teaching processes mostly because of their portability and affordance. In this paper, we seek to explore the primary uses of chatbots in medical education, as well as how they are developed. We elaborate on current chatbot applications and research enacted in the domains of medical and healthcare education, We focus in the areas of virtual patients in medical education, patients' education related to healthcare matters but also chatbots as course assistance in for enhancing healthcare professionals' curricula. Additionally, we examine the metrics that have been used to evaluate these chatbots, which include subjective ones like the usability and acceptability by the users, and objectives ones, like their accuracy and users' skills evaluation. Overall, even though chatbots offer a flexible solution and a vast possibility to improve healthcare education, our literature review suggests that their efficacy has not been thoroughly tested. Also, limited examples of chatbots in European Healthcare curricula have been found. These call of the need for further research towards this direction.

Keywords: Chatbots, Conversational agents, Higher Education, Medical Education, Healthcare Education

1 Introduction

Dialogue systems and conversational agents, including chatbots, are becoming ubiquitous in modern society. Chatbots can also be identified in the literature as "chatbot virtual assistants", "conversational agents", "chat bots", "pedagogical agents", "intelligent tutor systems", "dialogue systems", "smart personal assistants" and "smart assistants". They comprise software tools that simulate textual and/or auditory conversations and with which users interact on a certain topic or in a specific domain through digital services in a natural, conversational way using text and voice input [1, 2].

Their conceptualization emerged in the 1950s from the need of humans to interact with computers in a natural human language, while the term "Chatterbot" was coined a few years later in 1994. The internet era and the massive expansion of social networking sites sparked the widespread use of chatbots just a decade ago. The basic principle employed in chatbots consists of an environment that receives questions in natural human language, associates these questions with a knowledge base, and then provides a response [3]. Commonly, chatbots appear in customer services as frequently asked questions (FAQ), as virtual and personal assistants on mobile devices, and in business webpages for sailing products and to offering legal advice [4]. They are becoming a trend in many fields such as medicine, product and service industry, and lately in education. The exploitation of Artificial Intelligence (AI), machine learning techniques, and deep learning technologies allow for the design and development of chatbots which can be meaningfully integrated into education, and specifically, in medical and healthcare education which is the focus of this paper.

There is an increasing need to learn, practice and even design modern and technology-rich clinical environments. The ongoing global pandemic has highlighted the need to enhance preparedness for complicated and unexpected scenarios and the challenges healthcare professionals and patients alike face. It is therefore imperative to invest in intelligent and technologically advanced approaches to endorse personalized healthcare education that is more than ever needed nowadays. In fact, digital integration in learning and teaching has a high priority within Europe 2020 and is highly relevant within the context of healthcare where it is a declared political aim to promote Information Technology (IT) infrastructure in hospitals and the development of e-Health solutions both within the EU and globally [5].

Recently, there has been a growing interest in integrating chatbots in healthcare education, mostly because of their ease to develop and deploy without the use of any special equipment. As a result, chatbots can be a low cost and affordable technology for all the Higher Education Institutes (HEI) to embed them in their healthcare curricula to enhance their students' knowledge and skills. In addition, chatbots can enhance individual learning since students can use them as standalone resources with no additional cost and receive personalized content.

Further to the above, there is growing evidence around chatbots' potential to change the way students learn and search for information [6]. Chatbots can quiz existing knowledge, enable higher student engagement with a learning task and support higher-order cognitive activities (e.g., a better understanding of their learning habits, reflect on practice). Chatbots can also be very scalable, able to support hundreds of students concurrently, assisting with individual problems, answering questions and contributing to personalized learning. We believe that chatbots have a lot to offer both in Higher Education, and also in improving the publics' health literacy. In the following sections, we present a meticulous regarding the use and impact of chatbots in healthcare education and particularly in virtual patients, patients' education, and course assistance in HEIs.

2 Method

We performed a systematic literature review, following the PRISMA [7] methodology, of the use of chatbots and conversational agents in general, in medical education.

The main aim of the study is to identify the opportunities chatbots offer in the area, what are their primary uses, along with their general implementation framework and some of the metrics that have been used to evaluate them.

2.1 Search Strategy

The search looked up publications from the electronic databases ACM Digital Library, IEEE Xplore Digital Library, ProQuest, PubMed, Sage Journals, Springer and Taylor & Francis Online. Results were restricted to publications from January 2015 to September 2020 and written in English. The pattern Chatbot AND Healthcare AND Education was used as the composition for the search terms. Each of the three terms was expanded to a set of words of similar context as follows: Chatbot was defined as chatbot OR "conversational agent" OR "virtual agent" OR "dialogue system" OR "virtual patient". Healthcare was defined as health OR healthcare OR medical OR clinical and Education as educate OR school OR student OR learn OR teach OR simulate. Additional publications were retrieved and added to the search results from references and related sources.

2.2 Study Selection Criteria

The study looked at publications that focused on the development of chatbots or the conversation component of a virtual agent. Studies that included embodied conversational agents (ECA) or virtual agents and did not provide sufficient details about the conversational component were excluded. Additionally, the selected publications evaluated the chatbots through a user study or pilot. Review articles and publications where the full-text was not available were also excluded.

2.3 Screening Strategy and Article Review

After the removal of duplicate entries, the initial results were screened by three researchers, based on their titles and abstracts. From the remaining publications, the same team of researchers assessed their eligibility by doing a full-text screening. Publications that did not meet the selection criteria were excluded. Any disagreements were resolved through discussion between the researchers.

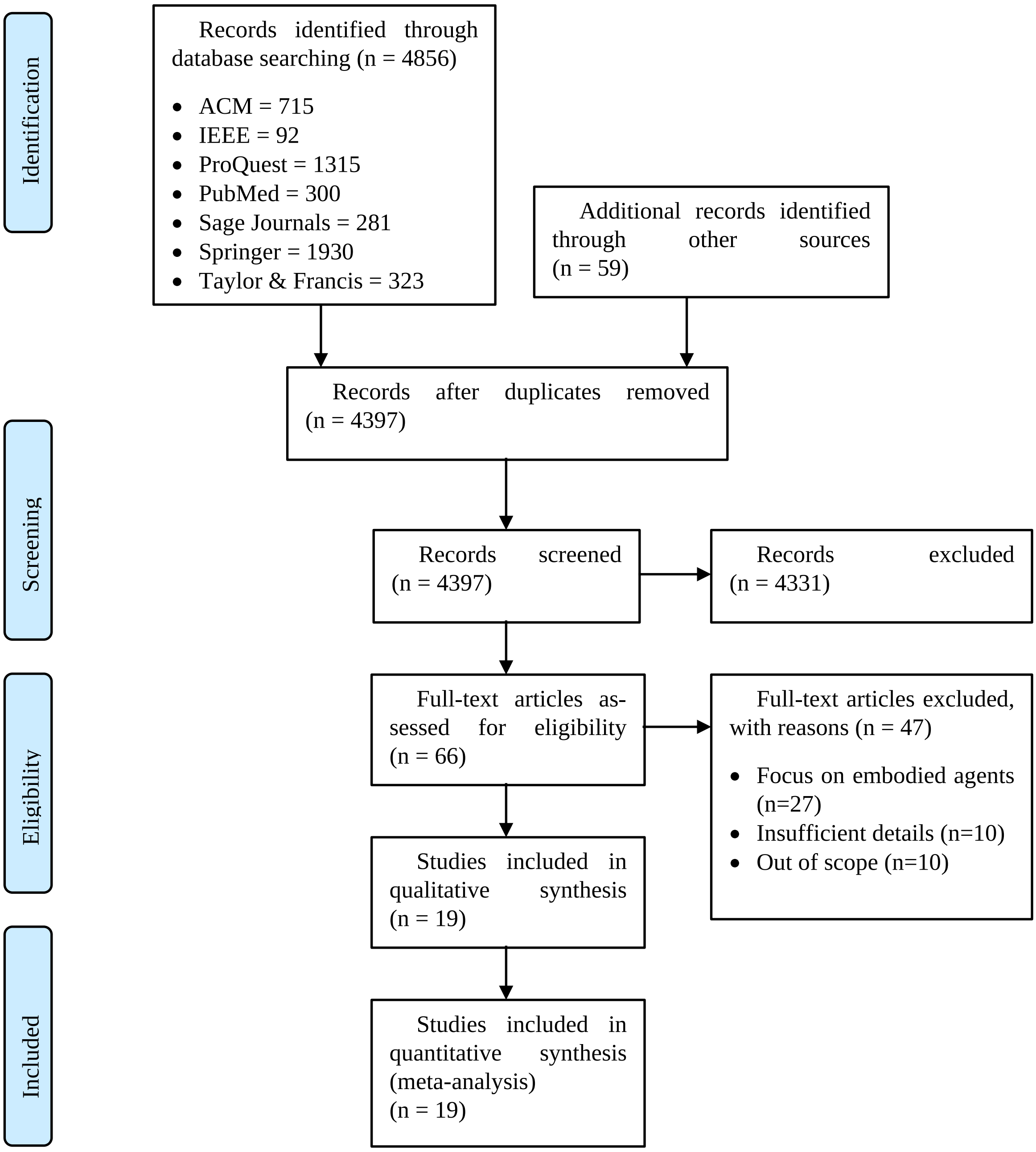

Fig. 1. Search procedure in the electronic databases

2.4 Data Extraction and Synthesis

After the final set of studies was selected, the included studies were analyzed and categorized based on different criteria. The focus was on the use of each chatbot, their underline implementation, and how they were evaluated.

3 Results

Through the search in the electronic databases, 4856 publication records were retrieved (Figure 1). Additionally, another 59 records were identified from the references and included for screening. After duplicates were removed, 4397 records were screened based on their titles and abstracts. From those 4331 were excluded and 66 were assessed based on their full-text for eligibility. From those 47 did not meet the selection criteria and were excluded. More than half (n=27) were excluded because they focus on embodied agents, without enough information on the conversational component, 10 provided insufficient details about the development and 10 were out of scope. The process resulted in 19 records being included in the study for qualitative analysis (Table 1).

Table 1. List of records included in the review.

Authors	Year	Use of chatbot	Focus area	Metrics for chatbots' evaluation
[8] Amith et al.	2019	patient education	counselling parents for providing HPV vaccine to children	usability of the system
[9] Beaudry et al.	2016	patient education	counselling teenagers with common health-care issues	acceptability of the chatbots/user engagement
[10] Campillos-Llanos et al.	2020	virtual patients	history taking and diagnosis of virtual patients	usability of the systems, the accuracy of the system (NLU components and user input) vocabulary coverage for new cases, vocabulary usage
[11] Carnell et al.	2015	virtual patients	history taking by novice users	usability, user skills (history taking, conversation duration, topic discoveries), accuracy of the replies
[12] Chetlen et al.	2019	patient education	frequently asked questions for a breast biopsy procedure	usability of the systems
[13] Datta, et al.	2016	virtual patients	communication between healthcare personnel during a virtual patient visit	accuracy of the system (NLU components and user input)
[14] El Zini et al.	2019	virtual patients	history taking to gain clinical experience	accuracy of the system (NLU components and user input)

[15] Foster et al.	2016	virtual patients	history taking to improve communication skills and learn to empathize	user skills (history taking, communication skills and empathy)
[16] Isaza-Restrepo et al.	2018	virtual patients	history taking to gain clinical experience	usability of the systems, user skills (history taking skills)
[17] Jin et al.	2017	virtual patients	history taking and diagnosis of virtual patients	accuracy of the system (NLU components and user input)
[18] Laleye et al.	2020	virtual patients	history taking to gain clinical experience	accuracy of the system (NLU components and user input), the accuracy of the system (dialogue management component)
[19] May et al.	2020	patient education	counselling on general consent and clinical data donation	usability of the systems
[20] Pereira et al.	2016	course assistance	multiple choice quiz for assessing students knowledge	acceptability of the chatbots
[21] Rose-Davis et al.	2019	patient education	counselling parents with children with Juvenile Idiopathic Arthritis	usability of the systems, accuracy of the system (dialogue management component)
[4] Rosruen et al.	2018	patient education	medical consultation for home treatment	usability of the system, accuracy of the system
[22] Tanana et al.	2019	virtual patients	communication skills during psychotherapy counselling	usability of the systems, user skills (communication skills)
[23] Wang et al.	2015	patient education	health literacy improvement related to family history	usability of the systems, user skills (history taking accuracy)
[24] Yadav et al.	2019	patient education	counselling mothers about breastfeeding	usability of the systems, acceptability of the chatbots
[25] Yang et al.	2019	virtual patients	clinical practice to gain clinical experience	usability of the systems, acceptability of the chatbots, accuracy of the system (dialogue management component), user skills (history taking skills), user skills (communication skills)

The analysis showed a few key areas where chatbots are used in medical education. Several studies focused on the development of virtual patients [10, 11, 13–18, 22, 25]. Another area chatbots have been used in is patients education [4, 8, 9, 12, 19, 21, 23, 24]. Other uses have also been explored like course assistance by administering quizzes [20] and facilitating communication between students and instructors.

Interaction with the chatbots is primarily done through free text inputted through keyboard [4, 10, 16, 17, 22, 24, 25] and using speech [17, 24]. Some chatbots, however, followed more linear flow with either pre-selected answers or specific commands that can be selected [9, 11, 12, 20, 23]. On the other hand, the logic behind the chatbots regarding understanding user input and the decision making primarily was done through some implementation of a natural language understanding system [4, 10, 13–15, 17–19, 21, 22, 25]. Some other studies used the Wizard-of-Oz [8, 24] methodology with a human controller following specified rules simulating a limited-intelligence chatbots' behaviour.

There is also a variety in the ways chatbots have been deployed, that shows the versatility of the technology. Some were used through smartphones or tablets [4, 8, 9, 12, 20, 23, 24], either through custom applications, using sms messages [9], or integrated in social media applications like Telegram [20] and Line [4]. Others were web-based [10, 11, 16, 22], run as standalone applications on personal computers [14, 17, 25], and even integrations in Virtual Reality systems [18, 19].

The evaluation of chatbots can vary based on the focus of each study and how far along each is. One of the main evaluation metrics is the usability of the systems [8, 10, 12, 16, 19, 21–25], which however does not follow any set guidelines, combing Likert-scale questions, and open-ended inquiries. Another metric that is used, especially in early-stage studies or with more digitally illiterate populations, is the acceptability of the chatbots [9, 20, 24, 25]. This can also include the ability of users to create rapport with the users and open up with it and talk about sensitive subjects [24].

One of the main ongoing challenges of chatbots is the natural interaction with the user, and their ability to understand what the user is saying. Therefore, several studies have focused more on the overall accuracy of the system, both related to the accuracy of the NLU components and understanding the user input [10, 13, 14, 17, 18], but also the dialogue management component that selects the correct responses to the users [18, 21, 25].

Finally based on the target audience of each chatbot, and the goals of each study, the user skills are measured like history taking skills [11, 16, 25], communication skills [15, 22, 25], empathy [20].

Following is an analysis of the main areas chatbots are being used in, with more details on their focus, as well as their implementation framework.

3.1 Virtual Patients

Chatbots as virtual patients have been used across healthcare practitioners' education including for physicians [15, 16, 18], and speech pathologist [11]. They also cover a wide range of conditions from psychological like depression [15], substance abuse [15], to other pathological areas including dysphagia [11], conditions related to abdominal pain [16, 18] and more robust systems that can simulate various case across domains [10, 14, 25]. Other variation can also be found in the interface that has been used. This can range from chat-like interfaces [11, 15, 16, 22] just showing an avatar of the patient, to 3D avatars [10, 14, 17, 18, 25]. Also, even though most receive user input through typing, some have used speech recognition [14, 18]. Another feature that has been observed across several studies [15, 16, 22, 25], and has shown overall positive results is the inclusion of automatic feedback modules either during or usually at the end of the interaction with virtual patients.

One of the goals of health-professional education is the development of student's communication and clinical reasoning skills. Starting from the 1960s [26] schools adopted the use of standardized patients by using actors that acted as real patients. This allowed interviewing patients in a controlled setting. However, the use of standardized patients can be time-consuming and costly for institutions [27]. To address these concerns, virtual patients have been developed that can simulate real-life interactions [28]. Virtual patients can have different forms ranging from simple conversational avatars, with a text-based interface, to more complex multi-modal agents. Chatbots, and conversational agents in general, provide the communication logic behind virtual patients.

Designing a chatbot can be a tedious and complex task to achieve a natural and robust interaction. Some, especially earlier, systems were designed to provide the user with a set of pre-defined options to select from. With the advancement of computational capabilities, however, researchers have started utilizing Natural Language Understanding (NLU) to analyze text from users as well.

Carnell et al. [11] compared two approaches. They used transcripts from previous interactions with virtual patients to create question-answer pairs that they then present to students as selection-based options. They then compared how a selection-based interface compares with a natural language interface. Results showed that the chat-based interaction resembled a real interaction, but the selection-based interface provided more guidance on what questions should be asked. Thus, novices that have no prior experience with interviewing might find the latter more useful until they gain enough experience. The findings were further supported by Isaza-Restrepo et al. [16] that incorporated a virtual patient in their curriculum, with students interacting with a number of virtual patients over the course of a semester. A pre- and post-assessment with standardized patients showed significant improvement. Students noted its usefulness, especially for novice students that have little or no prior experience with interviewing patients. The chatbot also reinforced the importance of post-session feedback as well as the benefits of repetition of scenarios and the ability to try different responses.

When using an NLU-based approach, understanding the user's intent, and then generating an appropriate response can be a difficult task. To achieve these rule-based systems utilizing pattern-matching have been used. Campillos-Llanos et al. [10] designed a dialogue system for a virtual patient that can support interactions for multiple cases from different medical domains. Their rule-based approach was designed by extracting questions and answers from standardized patient interviews and other clinical examination guides. Their knowledge model "hosts structured thesauri with linguistic, terminological and ontological knowledge". After an evaluation with 35 different cases from 18 specialities, the NLU module achieved an F-measure of 95.8%, while the dialogue manager answered correctly 74.3% of the time.

Foster et al. [15] examined different ways of teaching empathy through virtual patients. Interaction with the system was through a text-based interface, matching the input to predefined patterns. To detect paraphrasing, a machine-learning module was used to detect similarities between input. To teach empathy, human assessors reviewed students' responses and at the end of each interaction, provided more empathetic alternatives. This empathetic-feedback system led to increased empathy from students and building a better rapport with standardized patients.

With the compilation of large enough datasets, AI and machine learning approaches have also been implemented to create more robust and scalable systems [29]. Zini et al. [14] implemented a deep-learning framework to develop a medical domain-specific question-answering corpus based on medical documents. The framework works by first computing the word embeddings from the input and then computes sentence embeddings using a long short-term memory network (LSTM). Finally, a convolutional neural network (CNN) model computes the most appropriate answer. The system provided an overall accuracy of 81% answering the student's questions.

Tanana et al. [22] used two different LSTM networks to generate responses. The system also provided real-time feedback back to the users prompting them for more open questions and to use reflections. The group that was provided with the feedback improved their performance even after the feedback was removed. Their chatbot was still a proof-of-concept however tested with non-mental health trainees.

Research has also been made in hybrid models combining traditional rules-based approaches with deep learning ones. For example, Yang et al. [25] designed a system using pattern-matching with a Multiple Classification Ripple Down Rules knowledge base which utilizes a CNN model to select an appropriate answer based on the inferences. The system also includes an automatic competency assessment that can provide feedback back to the students. The evaluation of the system showed promising results, with students reporting more confidence and improvement in their skills.

Laleye et al. [18] implemented a hybrid system that primarily uses a rule-based pattern matching approach to find appropriate answers to input questions. However, when no appropriate match is found, the system switches to a semantic similarity subsystem based on word embeddings, to find the most similar question. They achieve this by combining FastText and CNN models, resulting in an F1-score of 92.29.

Jin et al. [17] also used a hybrid approach by combining pattern matching with a stack of CNNs. The dataset for the model consisted of prior dialogues of students with a virtual patient chatbot. For the NLU it uses a combination of CNNs for characters and words that are stacked. At the end, they use a binary classifier that chooses between the pattern matching and the CNN models based on the expected accuracy of each one. The result is an 89.3% accuracy and a significant reduction in error.

3.2 Patients Education

Chatbots in patients education can take the form of a Frequently Asked Questions (FAQ) to answers patients questions about a topic. Other uses assist with the communication between healthcare professional and the patients. One example of such a chatbot is for diabetic patients to record their medical histories in a short description [4]. Chatbots provide information and counselling to hospital patients at the time of hospitalization and react to patient questions. These interventions aim to provide individual support to patients helping them to follow their therapy. For example, one study showed that patient education aims at strengthening the competence and self-care capabilities of a patient [6]. Through websites or by asking questions, patients learn about diseases and treatment as a basis for their decision-making. However, their motivation to learn is often limited due to the complexity of content or significant barriers for asking specific questions. To address this issue, a smartphone application named CLAIRE was developed in this study [19]. It combines virtual reality (VR), a chatbot and a voice user interface (VUI). In the virtual environment, the user can move freely, interact with objects, and talk to the character CLAIRE. Then, the character provides information on the respective learning topic, which is in its current implementation information on the donation of personal health data and concluded that VR with integrated VUI can extend the existing information channels for patient education [19].

Patient education chatbots were created by the effort to overcome barriers related to the collection of family health history information. Relational agents are computer-animated characters that use speech, gaze, hand gesture, prosody, and other nonverbal modalities to emulate the experience of human face-to-face conversation. They can be programmed and used for automated health education and behavioral counselling interventions, and they have been demonstrated to establish and maintain therapeutic relationships through these and other interactions. These agents have been successfully used to facilitate medication adherence, to explain health documents, to promote breastfeeding and to educate about and motivate exercise and weight loss. Wang, et al. [23] developed a chatbot called VICKY which is an animated computer character designed to collect family health history information by asking a series of questions about the user's family health history, targeting common chronic conditions including heart disease, diabetes, hypertension, stroke, and various cancers. Users respond to VICKY's verbal questions by selecting a preformulated simple response on a touch screen, with the choices updated at each turn in the conversation. Response options are short and easy to read. Minimal reading and typing are required, thus reducing the literacy burden. Moreover, additional opportunities are interwoven throughout the program to let respondents tell VICKY when they are uncertain about the meaning of a response option.

Rosruen and Samanchuen [4] implemented MedBot which is designed to be a general doctor, expert on symptoms and treatment. MedBot can provide suggestions and medical advice to patients. The objective of the chatbot is to provide consultations only on general symptoms. Beyond that, it will recommend the patients to visit a real doctor. MedBot was designed based on 34 intents including 16 intents of symptoms, 10 intents of sub-detail of stomachache, five intents of sub-detail of a headache, one intent of greeting with a chatbot, one intent of no illness, and one intent of finding the hospital by getting the link.

In another study, Yadav et al. [24] studied how a chatbot can be used to educate new mothers who are breastfeeding their children. The chatbot in the study, even though it was run as a Wizard of Oz experiment, emulated a low-intelligent agent that tried to provide information usually provided by health workers to mothers 24-7 through their smartphone. The study was largely explorative, studying the acceptability of the system, but showcases the potential chatbots can have especially with digitally illiterate populations. The users of the chatbot slowly developed a relationship with the chatbot and with time trusted more its recommendations and guidance. The chatbot other than just answering questions from the user, provided counter-questions and also additional information and facts through notifications.

3.3 Course Assistance in HEIs

Personalized learning has the potential to improve the decision-making skills of physicians [30] by allowing greater transfer and cognitive flexibility, which may be especially important for future healthcare professionals and lifelong learning [30]. Consequently, training of healthcare professionals who enter the era of personalized medicine is of utmost importance and therefore the traditional academic setting must adapt to include personalized healthcare education aids [31]. There is growing evidence around chatbots, understood in this context as conversational agents that they have the potential to change the way students learn and search for information. In the context of healthcare education, chatbots may quiz existing knowledge, enable higher student engagement with a learning task or support higher-order cognitive activities [20]. Existing chatbot solutions have been studied before for their technical potential [32]. In large-scale learning activities involving a high number of students, chatbots can solve the problem of individual student support and contribute to personalized learning. Therefore, chatbots can be a solution to the inadequate individual support that students received in large-scale courses and/or MOOCs, with no further financial and organizational costs for the providers. For students but also teachers to accept and utilize the advantages of such solutions, it is important to introduce trust towards the performance of chatbots. There are therefore specific design characteristics of chatbots that can enhance the users' trust and therefore support chatbot's potential into healthcare education.

A recent survey conducted in 2020 by [33] found that students identified pharmacology and medical law as the courses that the chatbots have the potential to support. In particular, the chatbots could facilitate memorizing concepts, such as pharmacological formulas but also laws, and enable focusing on local variances in healthcare in both pharmacology and law disciplines. Another useful solution that could facilitate education is the FAQ chatbot. Students often ask for clarifications or pose common questions to educators. These could be about assessment, due dates, or resources, for example. This type of FAQ chatbot aims at answering to some of these common queries.

Another application of chatbots in Higher Education Institutions for medical and healthcare educations relates to the provision of online short response questions. For example, students may be asked to respond to a multiple-choice question, giving a justification about the answer they had selected. A chatbot can facilitate this interaction and then provide some personalized feedback. This chatbot application also provides many potential benefits [34], including a more personalized approach for users and the 24/7 availability of the chatbot. Implementing this style of textually enhanced concept inventory as a chatbot would allow for other benefits, specific to this application. For instance, the ability of a chatbot to confirm the wording or conceptual understanding of a student. This could be especially relevant when a student gives an explanation which is different from a common example, or one previously seen. This quiz chatbot also supports in time learning, allowing students to learn and receive feedback at points crucial to their learning process. Another benefit relates to the possibility for educators to see and identified common areas that students struggle with. This would allow for class-wide interventions to be taken [34].

4 Discussion & Conclusion

In this paper, we report a systematic literature review of chatbots in the area of medical education. Our inquiry was guided by the need to identify the main uses of chatbots in medical and healthcare education, but also examine the metrics which have been used to evaluate the usability of those chatbots.

The potential of educational chatbots relies on the fact that chatbots can enhance the learning process, by improving the way students learn and search for information [6]. In addition, chatbots can assist simultaneously multiple students by solving individual problems and quests contributing to a personalized form of learning [35] as if each student were receiving private education. To illustrate that, as aforementioned, chatbots can quiz existing knowledge, enable higher student engagement with a learning task and support higher-order cognitive activities. More specifically chatbots have been applied in several educational areas, as virtual patients for medical education purposes, for patients' education for healthcare matters but also as course assistance in for enhancing healthcare professionals' curricula. Firstly, virtual patient chatbots have been developed and released to enhance the communication skills of a doctor. For many decades, the doctor's interaction with the patient has been puzzling, with the communication skills to be an assessment course [36]. Nowadays chatbots are used as virtual patients to increase the empathic responses of the doctor toward the patient [15, 37]. Secondly, chatbots have been also used to educate the patients. Chatbots were found to be useful in providing information, responses to patients queries and counselling to patients during hospitalization. As a result, chatbots were found to be able to provide emotional support to patients in need [23]. Finally, chatbots were also used as course assistants in HEIs, since chatbots were found to be a reliable assistive technology to enhance the healthcare professionals' curricula, via answering student questions or by taking the patient's role.

Concerning the metrics which have been used for evaluating the chatbot solutions included into the pool of the selected papers, these involve usability, accessibility evaluation of the systems, and an assessment of the overall accuracy of the systems. Furthermore, it has been found that in some of the studies included in this review, user skills, such as history-taking skills, communication skills and empathy, have been measured, as part of the chatbot solutions' evaluation. We suggest the need for additional metrics to be used for chatbot systems' evaluation, especially related to their effectiveness on the cognitive, affective, and social aspects of learning. As Hobert and Meyer von Wolff [38] propose, there is a need for comprehensive and in-depth evaluation studies in this direction.

To conclude, there is a growing interest in integrating chatbots in healthcare education mostly because of their portability and affordance. As explained above chatbots can enhance education through a regular computer having access on the internet or even through the learners mobile phone. Even though chatbots are offering a flexible solution and vast possibility to improve healthcare education, limited examples of chatbots in European Healthcare curricula have been utilized. We believe that this review reveals the effective use of chatbot digital technologies in open education, since it proves that the use of chatbots in healthcare education will enable students to increase their health and medical-related skills through flexible learning.

5 Acknowledgements

The work was supported by the Erasmus+ programme, Action Strategic Partnerships for higher education (Grant Number 2019-1-UK01-KA203-062091), CEPEH: Chatbots Enhance Personalised European Healthcare Curricula, the project EDUBOTS, which is funded under the scheme Erasmus + KA2: Cooperation for innovation and the exchange of good practices - Knowledge Alliances (grant agreement no: 612446), as well as from the European Union's Horizon 2020 research and innovation program under grant agreement No. 739578 and the government of the Republic of Cyprus through the Directorate General for European Programmes, Coordination and Development.

References

1. Serban, I.V., Sankar, C., Germain, M., Zhang, S., Lin, Z., Subramanian, S., Kim, T., Pieper, M., Chandar, S., Ke, N.R., Rajeshwar, S., de Brebisson, A., Sotelo, J.M.R., Suhubdy, D., Michalski, V., Nguyen, A., Pineau, J., Bengio, Y.: A Deep Reinforcement Learning Chatbot. arXiv:1709.02349 [cs, stat]. (2017)
2. Smutny, P., Schreiberova, P.: Chatbots for learning: A review of educational chatbots for the Facebook Messenger. Computers & Education. 151, 103862 (2020). https://doi.org/10.1016/j.compedu.2020.103862
3. Fryer, L., Carpenter, R.: Bots as Language Learning Tools. Language Learning & Technology. 10, 8–14 (2006)
4. Rosruen, N., Samanchuen, T.: Chatbot Utilization for Medical Consultant System. In: 2018 3rd Technology Innovation Management and Engineering Science International Conference (TIMES-iCON). pp. 1–5 (2018)
5. European Commission: Communication from the commission to the European parliament, the 13 council, the European economic and social committee and the committee of the regions eHealth Action Plan 2012-2020: Innovative healthcare for the 21st century, https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52012DC0736, (2012)
6. Winkler, R., Söllner, M.: Unleashing the Potential of Chatbots in Education: A State-Of-The-Art Analysis. Presented at the Academy of Management Annual Meeting (AOM) , Chicago, USA (2018)
7. Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., Group, T.P.: Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLOS Medicine. 6, e1000097 (2009). https://doi.org/10.1371/journal.pmed.1000097

8. Amith, M., Zhu, A., Cunningham, R., Lin, R., Savas, L., Shay, L., Chen, Y., Gong, Y., Boom, J., Roberts, K., Tao, C.: Early Usability Assessment of a Conversational Agent for HPV Vaccination. Stud Health Technol Inform. 257, 17–23 (2019)
9. Beaudry, J., Consigli, A., Clark, C., Robinson, K.J.: Getting Ready for Adult Healthcare: Designing a Chatbot to Coach Adolescents with Special Health Needs Through the Transitions of Care. Journal of Pediatric Nursing: Nursing Care of Children and Families. 49, 85–91 (2019). https://doi.org/10.1016/j.pedn.2019.09.004
10. Campillos-Llanos, L., Thomas, C., Bilinski, É., Zweigenbaum, P., Rosset, S.: Designing a virtual patient dialogue system based on terminology-rich resources: Challenges and evaluation. Natural Language Engineering. 26, 183–220 (2020). https://doi.org/10.1017/s1351324919000329
11. Carnell, S., Halan, S., Crary, M., Madhavan, A., Lok, B.: Adapting Virtual Patient Interviews for Interviewing Skills Training of Novice Healthcare Students. In: Brinkman, W.-P., Broekens, J., and Heylen, D. (eds.) Intelligent Virtual Agents. pp. 50–59. Springer International Publishing, Cham (2015)
12. Chetlen, A., Artrip, R., Drury, B., Arbaiza, A., Moore, M.: Novel Use of Chatbot Technology to Educate Patients Before Breast Biopsy. Journal of the American College of Radiology. 16, 1305–1308 (2019). https://doi.org/10.1016/j.jacr.2019.05.050
13. Datta, D., Brashers, V., Owen, J., White, C., Barnes, L.E.: A Deep Learning Methodology for Semantic Utterance Classification in Virtual Human Dialogue Systems. In: Traum, D., Swartout, W., Khooshabeh, P., Kopp, S., Scherer, S., and Leuski, A. (eds.) Intelligent Virtual Agents. pp. 451–455. Springer International Publishing, Cham (2016)
14. El Zini, J., Rizk, Y., Awad, M., Antoun, J.: Towards A Deep Learning Question-Answering Specialized Chatbot for Objective Structured Clinical Examinations. In: 2019 International Joint Conference on Neural Networks (IJCNN). pp. 1–9. IEEE, Budapest, Hungary (2019)
15. Foster, A., Chaudhary, N., Kim, T., Waller, J.L., Wong, J., Borish, M., Cordar, A., Lok, B., Buckley, P.F.: Using Virtual Patients to Teach Empathy: A Randomized Controlled Study to Enhance Medical Students' Empathic Communication. Simul Healthc. 11, 181–189 (2016). https://doi.org/10.1097/SIH.0000000000000142
16. Isaza-Restrepo, A., Gómez, M.T., Cifuentes, G., Argüello, A.: The virtual patient as a learning tool: a mixed quantitative qualitative study. BMC Med Educ. 18, 297 (2018). https://doi.org/10.1186/s12909-018-1395-8
17. Jin, L., White, M., Jaffe, E., Zimmerman, L., Danforth, D.: Combining CNNs and Pattern Matching for Question Interpretation in a Virtual Patient Dialogue System. In: Proceedings of the 12th Workshop on Innovative Use of NLP for Building Educational Applications. pp. 11–21. Association for Computational Linguistics, Copenhagen, Denmark (2017)
18. Laleye, F.A.A., Blanié, A., Brouquet, A., Behnamou, D., de Chalendar, G.: Semantic similarity to improve question understanding in a virtual patient. In: Proceedings of the 35th Annual ACM Symposium on Applied Computing. pp. 859–866. Association for Computing Machinery, New York, NY, USA (2020)
19. May, R., Denecke, K.: Extending Patient Education with CLAIRE: An Interactive Virtual Reality and Voice User Interface Application. In: Alario-Hoyos, C., Rodríguez-Triana, M.J., Scheffel, M., Arnedillo-Sánchez, I., and Dennerlein, S.M. (eds.) Addressing Global

Challenges and Quality Education. pp. 482–486. Springer International Publishing, Cham (2020)
20. Pereira, J.: Leveraging chatbots to improve self-guided learning through conversational quizzes. In: Proceedings of the Fourth International Conference on Technological Ecosystems for Enhancing Multiculturality. pp. 911–918. Association for Computing Machinery, New York, NY, USA (2016)
21. Rose-Davis, B., Van Woensel, W., Stringer, E., Abidi, S., Abidi, S.S.R.: Using an Artificial Intelligence-Based Argument Theory to Generate Automated Patient Education Dialogues for Families of Children with Juvenile Idiopathic Arthritis. Stud Health Technol Inform. 264, 1337–1341 (2019). https://doi.org/10.3233/SHTI190444
22. Tanana, M.J., Soma, C.S., Srikumar, V., Atkins, D.C., Imel, Z.E.: Development and Evaluation of ClientBot: Patient-Like Conversational Agent to Train Basic Counseling Skills. Journal of Medical Internet Research. 21, e12529 (2019). https://doi.org/10.2196/12529
23. Wang, C., Bickmore, T., Bowen, D.J., Norkunas, T., Campion, M., Cabral, H., Winter, M., Paasche-Orlow, M.: Acceptability and feasibility of a virtual counselor (VICKY) to collect family health histories. Genetics in Medicine. 17, 822–830 (2015). https://doi.org/10.1038/gim.2014.198
24. Yadav, D., Malik, P., Dabas, K., Singh, P.: Feedpal: Understanding Opportunities for Chatbots in Breastfeeding Education of Women in India. Proc. ACM Hum.-Comput. Interact. 3, 170:1-170:30 (2019). https://doi.org/10.1145/3359272
25. Yang, W., Hebert, D., Kim, S., Kang, B.: MCRDR Knowledge-Based 3D Dialogue Simulation in Clinical Training and Assessment. J Med Syst. 43, 200 (2019). https://doi.org/10.1007/s10916-019-1262-0
26. Cleland, J.A., Abe, K., Rethans, J.-J.: The use of simulated patients in medical education: AMEE Guide No 42. Medical Teacher. 31, 477–486 (2009). https://doi.org/10.1080/01421590903002821
27. Bosse, H.M., Nickel, M., Huwendiek, S., Schultz, J.H., Nikendei, C.: Cost-effectiveness of peer role play and standardized patients in undergraduate communication training. BMC Medical Education. 15, 183 (2015). https://doi.org/10.1186/s12909-015-0468-1
28. Kononowicz, A.A., Zary, N., Edelbring, S., Corral, J., Hege, I.: Virtual patients - what are we talking about? A framework to classify the meanings of the term in healthcare education. BMC Medical Education. 15, 11 (2015). https://doi.org/10.1186/s12909-015-0296-3
29. Agarwal, R., Wadhwa, M.: Review of State-of-the-Art Design Techniques for Chatbots. SN COMPUT. SCI. 1, 246 (2020). https://doi.org/10.1007/s42979-020-00255-3
30. Mehta, N., Geissel, K., Rhodes, E., Salinas, G.: Comparative Effectiveness in CME: Evaluation of Personalized and Self-Directed Learning Models. Journal of Continuing Education in the Health Professions. 35, S24 (2015). https://doi.org/10.1002/chp.21284
31. Haiech, J., Kilhoffer, M.-C.: Personalized medicine and education: the challenge. Croat Med J. 53, 298–300 (2012). https://doi.org/10.3325/cmj.2012.53.298
32. Reiswich, A., Haag, M.: Evaluation of Chatbot Prototypes for Taking the Virtual Patient's History. Stud Health Technol Inform. 260, 73–80 (2019). https://doi.org/10.3233/978-1-61499-971-3-73

33. Stathakarou, N., Nifakos, S., Karlgren, K., Konstantinidis, S.T., Bamidis, P.D., Pattichis, C.S., Davoody, N.: Students' Perceptions on Chatbots' Potential and Design Characteristics in Healthcare Education. Stud Health Technol Inform. 209–212 (2020)
34. Cunningham-Nelson, S., Boles, W., Trouton, L., Margerison, E.: A Review of Chatbots in Education: Practical Steps Forward. In: Proceedings of the AAEE2019 Conference. p. 9. , Brisbane, Australia (2019)
35. Zumstein, D., Hundertmark, S.: Chatbots - an interactive technology for personalized communication and transaction. IADIS International Journal on WWW/Internet. 15, 96–109 (2018)
36. Bernardini, A.A., Sônego, A.A., Pozzebon, E.: Chatbots: An Analysis of the State of Art of Literature. Workshop on Advanced Virtual Environments and Education. 1, 1–6 (2018). https://doi.org/10.5753/wave.2018.1
37. Kononowicz, A.A., Zary, N., Edelbring, S., Corral, J., Hege, I.: Virtual patients - what are we talking about? A framework to classify the meanings of the term in healthcare education. BMC Medical Education. 15, 11 (2015). https://doi.org/10.1186/s12909-015-0296-3
38. Hobert, S., Wolff, R.M. von: Say Hello to Your New Automated Tutor – A Structured Literature Review on Pedagogical Conversational Agents. Wirtschaftsinformatik 2019 Proceedings. (2019)