Chatbots and children with special educational needs interaction

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Abstract. Introduction and aim. Chatbots could have a strong potential for competence training, overcoming barriers, and wellbeing management for individuals with special educational needs. We carried out a review to describe the existing knowledge on design characteristics, and user involvement in research on chatbots related to individuals with special educational needs. **Methods.** We searched for publications on the topic in ACM Digital Library, Web of Science, PubMed, ERIC, Education Source, and proceedings from conferences on special needs education, and on health informatics. **Results.** A total of 9 studies were included in this review. Most of the studies used authoring tools to implement the chatbots or parts of them. Smartphones, tablets and PCs were the most common target devices for chatbots. End-users participated in the research mostly as experimental subjects to test the chatbot. Only one study involved participants as co-designers. **Conclusions.** Research on chatbots for individuals with special education seems to be in earlier stages. More high-quality research is needed, involving individuals with special educational needs in all stages of development and incorporating evidence-based training strategies.

Keywords: Chatbots; Human-Computer Interaction; Special Needs Education; Autism Spectrum Disorder; ADHD.

1   Introduction

Unlike other software programs, chatbots are computer programs that engage directly with people in a natural way. Evidence suggests that people respond to chatbots as though they are human beings [1]. Chatbots are being used to provide services that require a person talking or assisting the user such as customer service, information search, and for general purposes in the case of home-based devices like Google Home or Alexa [2]. Because of its ease of use, chatbots could have a strong potential for competence training, overcoming barriers and wellbeing management for individuals with special educational needs [3].

Many individuals with special educational needs are diagnosed with conditions such as attention deficit/hyperactivity disorder –ADHD-, autism, or dyslexia, among others, and experience difficulties with their learning [4]. Research shows that digital technologies could be beneficial for these individuals: they can positively impact on the academic performance [5, 6]; and they also seem to be effective for overcoming barriers [6, 7]. Research also shows that individuals with special educational needs are barely involved in research on technology [8] thus, potentially limiting its meaningfulness.

The objective of this review is to describe the existing knowledge on design characteristics, and user involvement in research on chatbots for individuals with special educational needs. Therefore, we aim to answer the following research questions:

- RQ1. What types of chatbots have been investigated for people with special educational needs?
- RQ2. How have end-users been involved in research on chatbots for special educational needs?

2　Methods

In order to describe the existing knowledge on chatbots for individuals with special needs we carried out a scoping review. The scoping review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis, extension for scoping reviews (PRISMA-ScR) [9]. This scoping review includes a secondary analysis of a broader review on the use of chatbots in special needs education.

2.1　Search strategy

We conducted a search across 5 databases: ACM Digital Library, Web of Science, PubMed, ERIC, and Education Source. We used several keywords related to chatbots in combination with a sample of relevant keywords related to special needs education. The used search query is presented in Figure 1. Additionally, we searched for grey literature published in available conference proceedings during the period 2015 to 2022. We searched the conference proceedings from three major congresses in special education field (World Congress on ADHD; International Meeting for Autism Research/International Society for Autism Research IMFAR/INSAR; and International Association of Special Education); and one major conference on Health Informatics (World Congress on Medical and Health Informatics, MedInfo). No year or language limitations were used.

keywords related to chatbots (Chatbot OR Conversational agent OR Relational agent OR Dialog system)

AND keywords related to special needs education (Special needs OR Special educa-
tion OR Learning difficulties OR Learning differences OR ADHD OR Hyperac-
tiv* OR Hyperkin* OR Attention deficit OR Attention deficit hyperactivity dis-
order OR Impulsivity OR Autis* OR ASD OR Asperger OR Pervasive develop-
mental disorder)

Fig. 1. Search query.

2.2 Inclusion criteria

We included in our review primary studies reporting results that referred to 1) chat-
bots, and 2) individuals with special educational needs. Reviews, opinion papers.
editorials, letters to editor, and study protocols not reporting results were excluded.
Additionally, we excluded scattered literature belonging to the same authors when
they did not contribute with relevant added findings in later studies.

2.3 Eligibility and data extraction

All identified references were uploaded to EndNote 20. After removing duplicates,
two independent reviewers (CB and EG) assessed their eligibility. Discrepancies were
discussed until we reached agreement. One reviewer (JCT) extracted the following
data from the selected articles: chatbot technology; device target; and user involve-
ment. A second reviewer (EG) verified the appropriateness of the extracted data.

2.4 Quality assessment

The quality of the included studies was assessed by one reviewer (EG) by drawing
on the GRADE guidelines [10].

3 Results

3.1 Sample description

A total of 43 references were identified in the database search, and 1 in the conference
proceedings. After removing 5 duplicates, a total of 39 records were assessed for eli-
gibility. Thirty-four references were excluded during the title and abstract screening.
A total of 9 publications dealing with chatbots and special needs education were re-
viewed in full text and were included in this review [11-19]. See Figure 1.
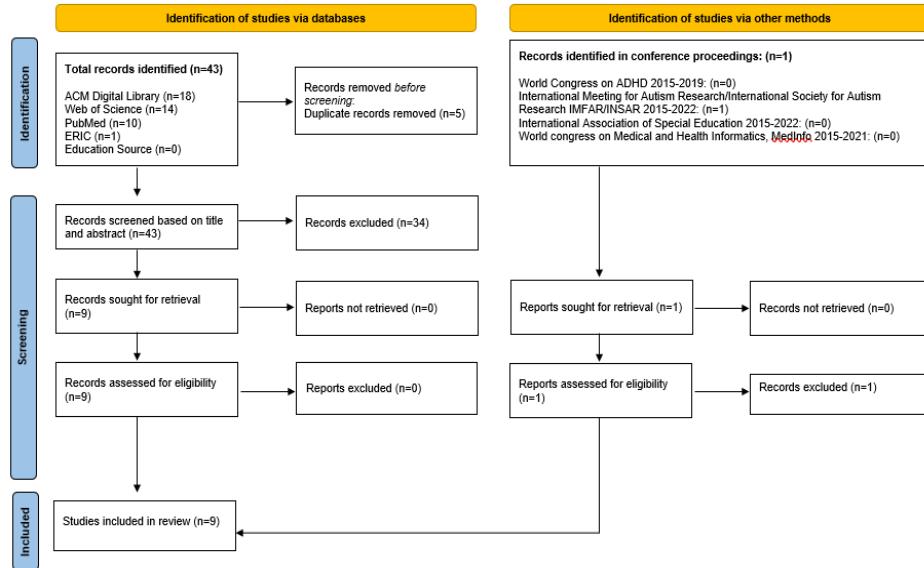
Fig. 1. Flowchart of the selection process.

3.2 Description of included studies

The included studies used very different technologies to implement their chatbots. Aside from commercial devices at global level like Amazon's Alexa [17] or regional level like NUGU CANDLE [11] or Todaki [14], the rest of the studies employed what is usually called an "authoring tool" to implement the whole chatbot [12, 15, 16] or parts of it [13, 18, 19].

Smartphones, tablets and PCs were the most common target devices for the chatbots: in two of the included studies, it was Windows PC [18, 19]; in two were tablets [15, 16]; and in two were smartphones [12, 14]. In the rest of the studies, the target device was a web browser (hence PC or tablet) [13]; Alexa from Amazon Echo [17]; and NUGU CANDLE [11]. See Table 1.

End-users participated in the research as experimental subjects to test the chatbot in six of the nine included studies [13-16, 18, 19]. Individuals with special educational needs evaluated the chatbot by participating in in-depth interviews in one study [17]; and in focus groups and surveys in another study [16]. One of the included studies involved parents of children with special educational needs as proxies to inform the design [12]. Only one study explicitly mentioned the use of participatory design workshops for involving end-users as co-designers of the chatbot [11].

Regarding the quality of the included studies, only one of the studies was considered of high quality [14]; the remaining studies were weighted as being of low or low quality according to GRADE guidelines [11-13, 15-19].

Table 1 shows a brief description of the included studies.

Table 1. Summary of the included studies (n=9)

Article	Technology	Device target	User involvement	GRADE points*
Jang et al., 2021 [14]	"Todaki" chatbot application, developed by Korean company Medimind Co.	Smartphone	Experimental subjects in a randomized pilot study. After the intervention evaluated the chatbot by answering a survey.	4
Ramadan et al., 2021 [17]	Amazon's Alexa	Alexa from Amazon Echo	Consumers with special needs participated in in-depth semi-structured interviews.	2
Tanaka et al., 2017 [18]	MMDAgent (Japanese spoken dialogue system) and facial expression analysis using Japanese Female Facial Expression and NOCOA+ Database	Windows PC	As experimental subjects within a social skills training program replacing the human assistant with the chatbot	2
Tanaka et al., 2015 [19]	MMDAgent and MikuMikuDance (human-like behavior for the dialogue agent like blinking and nodding)	Windows PC	As experimental subjects within a social skills training program replacing the human assistant with the chatbot	2
Hayashi et al., 2015 [13]	A Web-based tutoring system comprising a Web server, database, and rule-based scripts. In-house.	Web browser (hence PC or tablet)	Experimental subjects within a social skills training program.	2
Massaro, 2006 [15]	"Baldi", a 3D computer-animated talking head,	Tablet	As experimental subjects in a within-	2

	in-house design and development		subject performance test.	
Park et al., 2022 [16]	NAVER CLOVA chatbot builder	Tablet	As experimental subjects in an observational field study with post-session surveys and focus-group.	1
Gagan et al., 2022 [12]	"Amy" mobile conversational agent, in-house design and development.	Smartphone	Parents and domain expert used as proxies for children with ASD to inform the design of the software and its content.	1
Cha et al., 2021 [11]	Benchmark study of Kakao Mini vs Google Home vs NUGU CANDLE.	NUGU CANDLE: candle-shaped, commercial Korean device by SK Telecom	Participatory design workshops, participants with ASD as co-designers, repurposing of mainstream technologies	1

*Quality of the evidence (GRADE) 4=High; 3=Moderate; 2=Low; 1=Very low

4 Discussion

4.1 Summary of main findings

There is not much published research on chatbots for individuals with special educational needs yet. We have identified that the existing research focuses on three main areas of interest regarding the use of chatbots by people with special educational needs. First, there is a need for personalization that takes care of the social skills of the individual, as well as special language and speech features that might affect the interaction with the conversational agent. Second, conversational agents have a demonstrable potential to address emotion regulation for individuals with autistic features, and work in this regard is therefore needed. Lastly, we found out that there is a demand across studies for realism in chatbots, since the users make a more advantageous use of this technology when they feel they are having a believable interaction.

Overall, even though these first chatbots seem to have a great potential for individuals with special educational needs, further research is needed.

Most of the included papers in this review were considered of low or very low quality according to GRADE guidelines [10]. These low scores are mostly explained because GRADE assigns a higher score to randomized studies. In our review, only one of the included studies was randomized. More high-quality research, based on different research methods, and especially using randomized experiments testing different effects of chatbots for benefiting individuals with special educational needs are needed.

4.2   Technology and targeted device

We observed a common characteristic across the papers when it comes to use: none of them chose to explore these devices as general-purpose assistants. This contradicts the use this technology is given for the general population. Actually, the only device that is commercially widespread among the ones targeted in the studies was Amazon's Alexa [17]. The authors repurposed Amazon's Alexa according to the requirements of people with special needs, either as a friend, a companion, a provider of functional benefits or a full relied-on caregiver [17]. Another mainstream commercial device found in the results was NUGU CANDLE [11], but it has a more limited scope, since it is only sold in Korea. Its functionality is similar to Alexa's, and the authors explored its use from a co-design perspective to tailor it to the individual needs of adolescents with autism spectrum disorders. Again, not as a general-purpose device, but as a provider of functional benefits, as Ramadan et al. called it. The Todaki chatbot used by Jang et al. [14] is a mobile app that can be obtained in the Google Store, but it is already tailored for ADHD participants, so the general purpose was not even considered from a study design perspective. The rest of the chatbots are in-house developments that target a specific kind of training, such as social skills training [13, 16, 18, 19]. This leads us to the conclusion that more research needed to study how the repurposing of commercial chatbots and the use of customized chatbots can help individuals with special needs, in a way that complements or challenges the results obtained in these studies. But, in addition, there is a knowledge gap about how commercial chatbots work if used for their intended purpose for these individuals that should be addressed.

Regarding the use of these devices, we observed another phenomenon that might concern practitioners. As we just mentioned, many of the studies target a specific training within special education such as social skills training. However, we did not find any study mentioning how this training relates to, differs from, or replaces current practices. Tanaka et al. [18] describe ad-hoc training sessions that follow the instruction, modeling, role- playing, feedback, and homework by Bellack [20], and mention that they appear to have potential to be used by teachers. And Tanaka et al. [18, 19] refer to the use of the social skills training model by Liberman [21]. Although these proposals relate to existing, theoretical training models, we suggest that re-

searchers in this area will have to explore the possibility of a stronger connection between these innovative training sessions using chatbots and current practices in special education schools and individual assistance. Questions such as "how can we adapt current effective training models to chatbots to improve the logistic performance of special education programs?", "to what extent does the use of chatbots instead of the currently used materials improve the training of these individuals in social skills training", or even "what are the perks of using commercial chatbots to carry out this training versus using customized agents developed by researchers on the targeted areas" point at the knowledge gaps that we found in this review.

4.3 User involvement

In our review we have found that the most common approach to involve end-users in research was as experimental subjects to test the chatbot. End-users were able to evaluate the chatbot by answering surveys and participating in interviews and focus groups in two studies; and in one additional study there were parents (acting as proxies of future chatbot end-users) who assessed the chatbot. Only one of the included studies actively involved individuals with special education needs as co-designers. Previous research has highlighted the low involvement of individuals with special educational needs in research on technology [8]. Our review, specifically focused on chatbots, confirms these findings.

Future research on chatbots for individuals with special educational needs must consider a more active involvement of end-users during all stages of development. It is well known that involving end-users in all stages of development and evaluation of technologies play an important role on innovation [22], and positively contributes to the system success [23]. Besides, it contributes to empower participants and meaningfully involve them [8].

4.4 Study limitations and future directions

We have used only four keywords related to chatbots on our search engine. Although these might be the most common keywords related to conversational agents, we might have missed relevant research on the field. Our search was limited to databases, and some of the main conference proceedings in special education field, and only one conference on health informatics. The use and testing of chatbots for individuals with special educational needs is an emerging field. Therefore, future review papers could benefit from searching further sources where novel research projects are presented, such as trials registries, PhD and master theses, research reports, or additional conference proceedings, among others.

5 Conclusions

This scoping review aims to ascertain which technologies are being used to implement chatbots targeting users with special educational needs and what use they are

given to help them. The search strategy yielded nine studies ranging from repurposing of commercial technologies to in-house implementation of custom chatbots. Most of the studies included the final users as experimental subjects, except for one study that discussed co-design.

In summary, research on chatbots for individuals with special education seems to be in the early stages. On one hand, the user involvement in the resulting studies is very limited, and more participatory approaches might improve the repurposing or design of these technologies for this population. On the other hand, the uses that these chatbots are given are mostly ad-hoc training sessions or usability inquiries, with no mention of factual practice change or potential connection to evidence-based training strategies for individual needs of individuals with special educational needs like hyperactivity and attention deficit disorders or autism spectrum disorders. More high-quality research is needed, involving individuals with special educational needs in all stages of development, and incorporating evidence-based training strategies.

6   References

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