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Are We Facing an Algorithmic Renaissance or Apocalypse? Generative AI, ChatBots, and Emerging Human-Machine Interaction in the Educational Landscape

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Abstract: This study explores the transformative potential of Generative AI (GenAI) and ChatBots in educational interaction, communication, and the broader implications of human-GenAI collaboration. By examining the related literature through data mining and analytical methods, the paper identifies three main research themes: the revolutionary role of GenAI-powered ChatBots in educational interactions, their capability to enrich social learning, and their dual role as both support and assistance within educational settings. This research further highlights the impact of human-GenAI interaction in education from social, psychological, and cultural perspectives, focusing on social presence as a fundamental component of the teaching and learning process. It discusses the integration of GenAI and ChatBots into education and considers whether this marks the dawn of an algorithmic renaissance that elevates educational experiences or an apocalypse that threatens the very essence of human learning and interaction.

Keywords: Generative artificial intelligence, GenAI, ChatBots, bots, conversational agents, natural language processing, machine learning, deep learning, interaction, human-GenAI interaction, communication, transactional distance, online learning, open and distance learning, distance education.

Highlights

What is already known about this topic:

- Interaction and communication are one of the most important elements of social learning and interaction can also be achieved with non-living entities.
- Generative AI can process, contextualize, interpret, and use human language better than generic AI.

What this paper contributes:

- This paper explores GenAI-powered ChatBots revolutionizing educational interaction.
- This research examines conversational agents' role in enriching social learning.
- This study highlights GenAI's dual role as support and assistant in educational processes.

Implications for theory, practice and/or policy:

- Because GenAI can mimic human language, there is a need to uncover new types of human-GenAI interactions.
- As an entity capable of interacting and communicating effectively, GenAI's emergent roles in social teaching and learning processes can be explored.
- Policies are needed to regulate the responsible use of GenAI-powered ChatBots in educational settings.

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Introduction: Teaching and Learning with Non-Human Agencies

In educational ecosystems, teaching and learning processes involve various stakeholders, including non-living entities (Downes, 2022). Connectivism, a theory proposed by Siemens (2004), argues that learning may reside in non-human appliances. This perspective is being credited with advancements in the field of artificial intelligence (AI), particularly with the emergence of generative AI technologies.

The development of the first computer, ENIAC, marked a significant milestone in AI research, suggesting that humanity's millennia-long quest might finally be realized: AI could embody its soul through a computer and evolve independently (Bozkurt, 2023a; Şenocak et al., 2023, 2024). Subsequent advancements in computing technologies and educational technology (Bozkurt, 2024a) and AI have led to the introduction of generative AI by the end of 2022 (OpenAI, 2022), signaling a new era in this domain. Generative AI holds particular importance in the educational landscape by introducing novel forms of interaction.

In digital and online learning environments, Moore (1989) identified three key types of interaction: learner-learner, learner-teacher, and learner-content. This framework has significantly influenced online distance education (Bozkurt, 2019), highlighting the dynamics and impact of these interactions. However, the digital transformation of education and the widespread use of online technologies necessitate a reconsideration of interaction types. For instance, Hillman et al. (1994) introduced a fourth type, learner-interface interaction, to account for the dynamics between learners and technological mediums. Similarly, Hirumi (2002, 2006, 2009) expanded the classification to include four types of interactions: learner-self, learner-human, learner-non-human (content, interface, and environment), and learner-instruction. Nonetheless, it is important to underline that the time when these propositions were made was a time when there were no technologies that were powerful compared to generative AI. Building on Dewey's (1938) concept of transaction, interaction is recognized as a crucial, complex, and multifaceted component of all learning practices. Anderson (2003) highlights its significance, especially in reducing transactional distance, a term coined by Moore (1989, 1993, 2007). Transactional distance refers to the perceived psychological space between educators and learners, described as a pedagogical construct that hinges on the interaction among the environment, individuals involved, and their behavioral patterns within a specific context (Moore, 2007). This construct is governed by three critical variables: Dialogue, Structure, and Learner Autonomy, each playing a key role in shaping the learning experience and influencing the extent of transactional distance.

Human-GenAI Interaction: The Emerging Fourth Type

Generative AI, with its profound ability to master human language, is one of the most complex and sophisticated technologies ever created, and it uses human knowledge to identify patterns that may elude human perception (Bozkurt, 2023b). These AI models are particularly adept at natural language processing (NLP) applications, including chatbots, virtual assistants, language translation, and text generation. The literature increasingly recognizes interaction and communication with generative AI-powered chatbots as an emerging area of research (Bozkurt, 2023c; Bozkurt, 2024b; Sharma & Bozkurt, 2024). This interest stems from their intuitive nature and ability to respond to complex queries in a manner similar to human interaction (Limna et al., 2023).

The capabilities of generative AI extend beyond mere language proficiency; they embody the potential to revolutionize the nature of interaction in educational settings. As these AI models become more integrated into learning environments, they introduce a new dimension of human-GenAI interaction, anticipated to be recognized as the fourth critical type of interaction in educational research. This evolving dynamic signifies the importance of developing a deeper understanding of how generative AI can enhance learning experiences through personalized, sophisticated engagement.

ChatBots

At its core, a ChatBot is a software application designed for online interaction via text or text-to-speech, becoming a prominent feature alongside generative AI advancements (Traymbak et al., 2024). Known variably as bots, chatterbots, smart bots, intelligent computational agents, digital assistants, or conversational assistants (Gupta et al., 2020; Mazón, 2021), ChatBots differ from physical robots by existing as virtual entities. These bots engage users through a Conversational User Interface (CUI), facilitating interaction without the need for physical presence (Sandu & Gide, 2019).

Historically, ChatBots like ELIZA marked the inception of conversational technology (Weizenbaum, 1966), which has significantly evolved with generative AI, powered by NLP and Large Language Models (LLMs). This evolution has expanded ChatBots' capabilities and diversified their types (Belda-Medina & Calvo-Ferrer, 2022; Jeon et al., 2023; Jeon & Lee, 2023), making them increasingly utilized for educational purposes (Koh et al., 2023) due to their ability to foster social learning and communication (Sandu & Gide, 2019) which are essential components for social learning (Bandura, 1977; Vygotsky, 1978).

Contemporary generative AI-powered ChatBots surpass earlier versions by engaging in extended, open-ended conversations (Jeon & Lee, 2023), adapting responses from input data rather than relying on fixed replies (Traymbak et al.,2024). This adaptability enables ChatBots to assume various pedagogical roles (Wollny et al., 2021), including teaching assistants, personalized tutors, assessment partners, and co-researchers, thereby supporting learning, assistance, and mentoring in educational settings (Ansari et al., 2023; Tlili et al., 2023).

The integration of ChatBots in the educational landscape introduces numerous opportunities and challenges (Chamorro-Atalaya et al., 2023a, 2023b; Khennouche et al., 2024; Okonkwo & Ade-Ibijola, 2021; Wollny et al., 2021). For instance, they can enhance student learning experiences by allowing personalized, stress-free study at an individual pace, providing real-time responses, promoting dialogic learning, and maintaining motivation (Ait Baha et al., 2023; Chen & Huang, 2023; Ortega-Ochoa et al., 2023). Moreover, ChatBots have shown the potential to improve reasoning, achievement, knowledge retention, and interest in learning (Ait Baha et al., 2023; Chen & Huang, 2023; Ortega-Ochoa et al., 2023). Additionally, chatbots could significantly improve explicit reasoning, learning achievement, knowledge retention, and learning interest (Deng & Yu, 2023). However, optimizing conversational flow, advancing dialogue mechanics, improving domain adaptability, and addressing ethical considerations remain challenges to be addressed (Khennouche et al., 2024). Lastly, ethical issues still seem to be a great concern, especially in the educational context (Liu et al., 2024).

Purpose of the Paper

Based on the aforementioned considerations, this paper explores the emergence of generative AI and chatbots in the educational landscape and seeks to answer the question: Are we facing an algorithmic renaissance or apocalypse? For this purpose, the paper intends to identify research trends and patterns related to generative AI, ChatBots, and human-machine Interaction.

Methods

Research Design

This study aims to deepen our understanding and explore emerging trends and patterns in the use of ChatBots and generative AI within the educational landscape. To achieve this, we implemented a methodological framework combining systematic literature review, as outlined by Gough et al. (2012), with bibliometric analysis techniques, following the approach suggested by Donthu et al. (2021).

Additionally, the study incorporates advanced data mining and analytical methods (Fayyad et al., 2002), including t-SNE analysis (van der Maaten & Hinton, 2008), text mining (Feldman & Sanger, 2007) and Social Network Analysis (SNA) (Hansen et al., 2010), to explore the intricate dynamics of the research landscape.

The employment of multiple analytical techniques serves a dual purpose. Firstly, it allows for data triangulation, significantly enhancing the reliability and validity of the results (Thurmond, 2001). Secondly, it facilitates a multidimensional examination of the research corpus, offering a comprehensive understanding of the subject matter. This multifaceted approach enables a thorough investigation into the various aspects of ChatBots and generative AI's application in education, addressing the research questions from diverse perspectives.

Inclusion criteria and research sampling

Our research focused on analyzing publications indexed in the Scopus database, chosen for its extensive coverage of scholarly articles. This selection was based on the availability of these publications either through library services or open-access platforms, and their relevance to our research themes, as indicated by specific search strings in their titles, abstracts, or keywords (see Table 1 for search strings). To assemble our research corpus, we employed search strings that were explicitly related to the use of ChatBots and generative AI within the educational context. Adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021), we meticulously screened and selected publications. The process culminated in a final corpus comprising 66 publications that met our criteria for inclusion.

Table 1. Search strings and PRISMA protocol.

Database	Scopus (2011-2024).
Search Strings	Article Title: "bot" OR "chatbot*" OR "conversational agent*" OR "conversational assistant*" OR "virtual assistant*" OR "digital assistant*" AND Article title, abstract, and keywords: "interaction*" OR "communication*" AND "education" OR "teaching" OR "learning" AND Article title, abstract, and keywords: "AI" OR "generative AI" OR "GenAI" OR "artificial intelligence" OR "ChatGPT" OR "generative artificial intelligence"
Identification	A total of 402 documents were identified.

Screening	• Non-peer-reviewed documents were excluded:
	  ○ Book Chapter (n=18), Book (n=3), Note (n=2), Short Survey (n=1), Letter (n=1), Short Survey (n=1).
	• Documents written in other than English were excluded (n=5).
	• The subject area was limited to Social Sciences:
	  ○ 293 papers from different subject areas were excluded.
	• Non-relevant and out-of-scope documents were excluded (n=12).

Inclusion	A total of 66 documents were included in the final research corpus.

Limitations

While this paper endeavors to offer comprehensive insights into the use of ChatBots and generative AI in education, it acknowledges certain limitations in the interpretation of its findings. Primarily, our reliance on Scopus, despite its status as the most extensive database for peer-reviewed literature, means our analysis is based on data sourced exclusively from this single platform. Although Scopus facilitated the compilation of a significant research corpus, it is crucial to recognize that relevant literature on

generative AI in education may also be available through other academic databases, sources, and formats, including grey literature not indexed by Scopus. Therefore, the scope of our findings is necessarily limited, offering a perspective that, while extensive, does not encapsulate the full spectrum of available research on the subject. This constraint highlights the importance of considering a broader range of sources and databases in future research to achieve a more holistic understanding of ChatBots and generative AI's role in education.

Findings and Discussions

The following sections report trends identified through bibliometric analysis and then report research patterns identified through data mining and analytics approaches.

Research and Publication Trends

The research corpus included a total of 66 peer-reviewed documents published in 50 separate sources by 220 authors. Only 3 papers were single-co-authored while the rest of 217 papers were multi-authored papers. The research corpus included a total of 230 keywords and 3138 references. From 2011 to 2024, the period covered 14 years. Computers and Education, British Journal of Educational Technology, and the International Journal of Educational Technology in Higher Education are the sources that published more than 20% of the papers included in the final research corpus.

Research Patterns

This section reports the three broad emerging research themes identified through t-SNE analysis (Figure 1), text mining (Figure 2), and social network analysis (Figure 3). Accordingly, the identified themes are as follows:

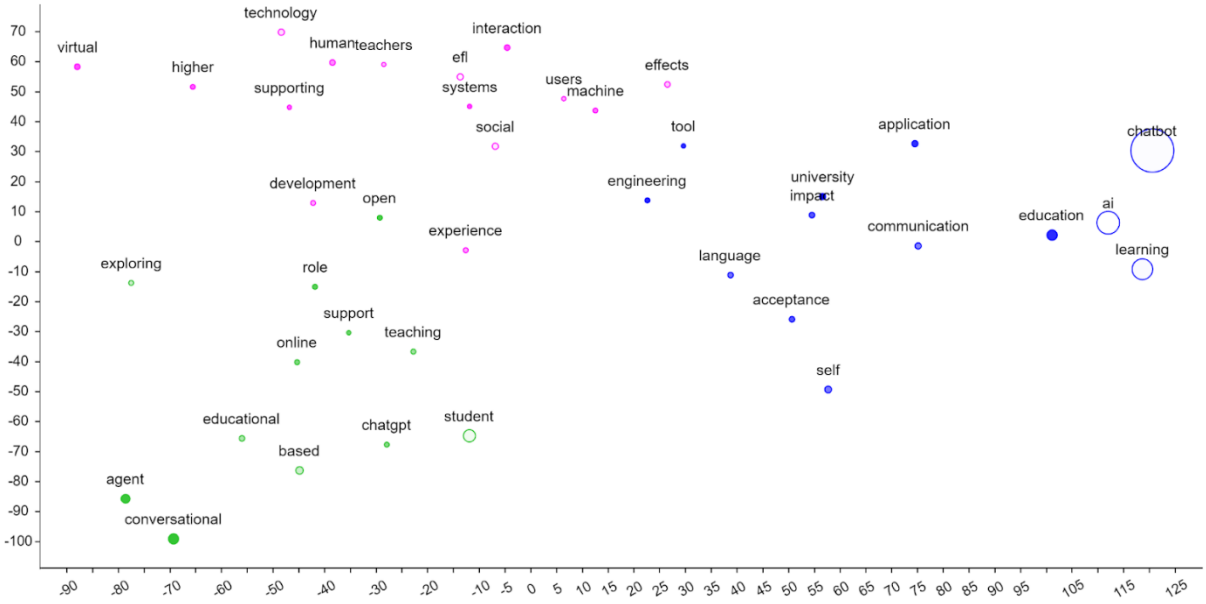

Figure 1. Analysis of the titles through t-SNE.

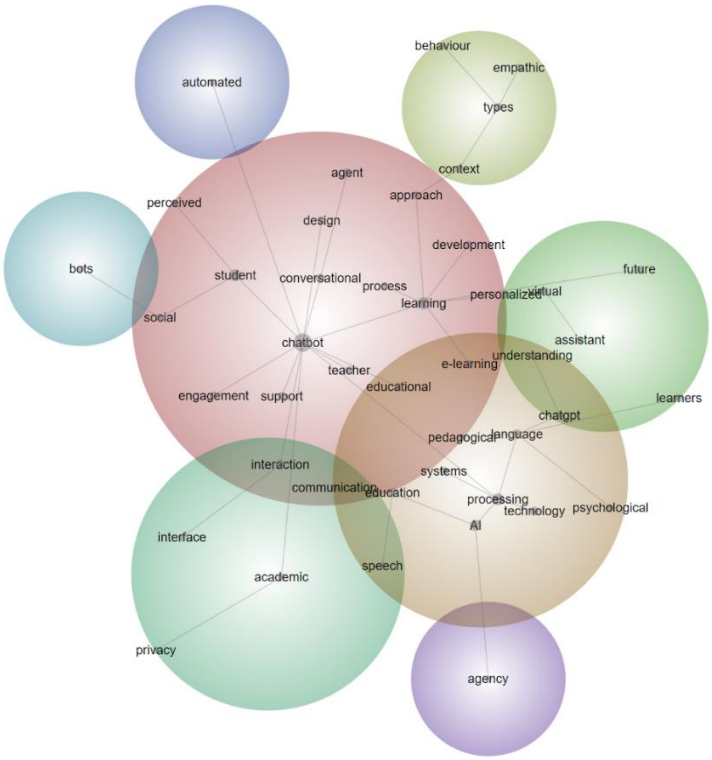

Figure 2. Analysis of the abstracts through text-mining.

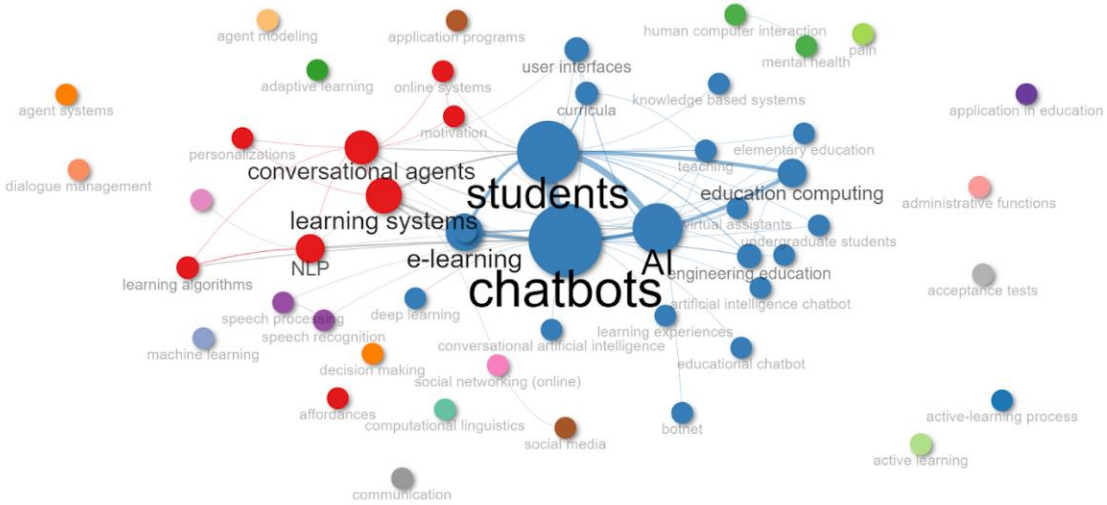

Figure 3. Analysis of the titles through social network analysis.

GenAI-powered ChatBots as a new entity for educational communication and interaction *(See key nodes in Figure 1: ChatBot, AI, learning, social, conversational, agent, communication, interaction; See connected paths in Figure 2: bots, social, student, chatbot, engagement, conversational, agent; See the strategic nodes in Figure 3: chatbots, AI, students, human-computer interaction, user interfaces, educational chatbot, conversational AI, conversational agents, natural language processing, speech recognition, speech processing).*

Generative AI-powered ChatBots in education marks a significant shift in how educational communication and interaction are conceptualized and delivered. These ChatBots leverage advanced AI technologies, including NLP, speech recognition, and conversational AI, to facilitate more

personalized, engaging, and interactive learning experiences. The key nodes and connected paths identified in Figures 1, 2, and 3 emphasize the potential of ChatBots to act as conversational agents that bridge the gap between traditional educational methods and the dynamic, social, and individualized needs of students. However, this innovation also introduces critical challenges such as ensuring the accuracy and appropriateness of content, addressing ethical concerns around data privacy and bias, and the need for pedagogical frameworks that effectively integrate these technologies into the curriculum. The discussions around GenAI-powered ChatBots in education thus encompass both their transformative potential and the imperative for thoughtful implementation and ongoing evaluation to maximize their educational impact while mitigating associated risks. The evolution of these ChatBots further necessitates a collaborative approach among educators, developers, and policymakers to harness their potential responsibly and innovatively.

GenAI-powered conversational agents as a social learning entity *(See key nodes in Figure 1: Chatbot, AI, education, impact, exploring, technology, effects; See connected paths in Figure 2: learning, approach, context, types, emphatic, behavior* and *AI, processing, language, pedagogical, ChatGPT, understanding, learners; See the strategic nodes in Figure 3: AI, ChatBots, educational chatbots, application in education, learning experiences, social networking).*

The second theme revolves around the role of Generative AI-powered conversational agents as entities facilitating social learning. These agents, by employing AI technologies like NLP, machine and deep learning, may offer a more interactive, empathetic, and personalized learning approach. They can simulate social interactions, providing a platform for learners to explore and understand content within various contexts and learning strategies. Nonetheless, against the aforementioned potentials, critical examination reveals concerns about the depth of understanding and the authenticity of social interactions they can offer. The challenge lies in ensuring these agents can truly foster social learning dynamics that contribute to meaningful educational outcomes, necessitating a careful balance between technological advancement and pedagogical integrity.

GenAI as a support technology and as an assistant on the side *(See key nodes in Figure 1: Chatbot, AI, teacher, student, support; See connected paths in Figure 2: automated, chatbot, support, engagement* and learning, personalized, virtual, assistant*; See the strategic nodes in Figure 3: Chatbots, AI, virtual, assistants).*

The third theme highlights the dual role of Generative AI as both a support technology and an assistant, enhancing the educational ecosystem. Through the visual inspection (See Figure 1, 2, and 3), it's evident that AI-powered ChatBots serve as virtual assistants, offering personalized support, engagement, and learning assistance to both teachers and students. These tools automate various aspects of the educational process, providing immediate, on-demand help, and thereby freeing up human resources for more complex tasks. On the other hand, one should critically consider that the reliance on AI for educational support also raises questions about the quality of interaction, the depth of personalized learning, and the potential for these technologies to replace human elements in education.

Based on the three identified research themes, namely, (1) GenAI-powered ChatBots as a new entity for educational communication and interaction, (2) GenAI-powered conversational agents as a social learning entity, and (3), GenAI as a support technology and as an assistant on the side, it can be argued that the advent of generative AI and ChatBots, the educational interaction and communication is in a phase of transformation. Accordingly, the integration of GenAI-powered ChatBots and conversational agents in the educational landscape revisits and redefines interaction types within digital learning environments. Drawing from Hillman et al.'s (1994) concept of learner-interface interaction and Hirumi's (2002, 2006, 2009) expanded classification, the advent of generative AI introduces an emerging layer to these interactions. It emphasizes a shift towards more dynamic, personalized forms of learner-AI engagement, which aligns with Dewey's (1938) notion of transactional learning experiences. Moore's (1989, 1993, 2007) discussion on reducing transactional distance through interaction becomes

particularly relevant here, as GenAI technologies potentially minimize the psychological space between educators and learners by fostering a more connected, immediate, responsive learning environment and, thereby, reducing the structure and increasing the autonomy. This evolution towards human-GenAI interaction implies the importance of dialogue, structure, and learner autonomy in enhancing educational experiences and outcomes, suggesting a transformative impact on the pedagogical construct of transactional distance.

Conclusion, Suggestions, and Implications

Based on the three identified research themes, namely, (1) GenAI-powered ChatBots as a new entity for educational communication and interaction, (2) GenAI-powered conversational agents as a social learning entity, and (3), GenAI as a support technology and as an assistant on the side, It can be argued that the educational landscape is on the verge of transformative change, supported by the integration of generative AI and ChatBots. These technological advancements redefine the ways in which education is delivered and consumed, offering a new layer of dynamic engagement.

In the age of generative AI, curiosity emerges as a fundamental driver of learning and innovation. Both educators and learners are encouraged to cultivate a mindset of exploration, critical thinking, and adaptability to thrive amidst the complexities and opportunities presented by AI technologies. The rapid evolution of these technologies also highlights the necessity of continuous learning and skill development, prompting institutions to prioritize re/up-skilling initiatives to prepare individuals for the changing demands of the workforce and society.

The new frontier in human-GenAI interaction is certain to have implications in the field of education, so we propose to investigate the effects of human-GenAi interaction from social, psychological, and cultural perspectives. More specifically, these perspectives could focus on social presence, i.e. the degree to which teaching and learning are perceived as real because teaching and learning are social processes.

As already manifested in this paper, when we consider the integration of generative AI and ChatBots into education, we find ourselves at a crossroads, questioning whether we are on the brink of an algorithmic renaissance that enriches and enhances the educational experience, or if we face an apocalypse where the essence of human learning and interaction is compromised.

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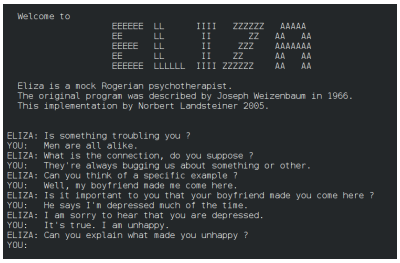

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Ethics Statement

Because this study doesn't involve any living entities, an ethics review is not applicable.

Conflict of Interest

The authors do not declare any conflicts of interest.

Data Availability Statement

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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