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# Digital companions in early childhood education: a scoping review on the potential of chatbots for supporting social-emotional learning

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**Introduction:** Artificial intelligence (AI)-powered chatbots are increasingly integrated into early childhood education; however, their contribution to children's social-emotional learning (SEL) has not been systematically synthesized. While evidence suggests that such technologies can support self-awareness, emotional regulation, and social interaction, research remains fragmented in terms of developmental appropriateness, ethical safeguards, and pedagogical alignment. This review addresses this gap by mapping the current state of knowledge on chatbot-supported SEL in early learning contexts.

**Methods:** Following the PRISMA-ScR protocol, a comprehensive search was conducted across Scopus, Web of Science, ERIC, ScienceDirect, and SpringerLink for peer-reviewed studies published between January 2019 and March 2025. Inclusion criteria required studies to involve children aged 0–8, investigate chatbot-based interaction in educational settings, and examine at least one SEL domain. Data were charted and thematically synthesized according to research design, participant profile, technological features, and SEL competencies.

**Results:** Of 205 records initially identified, 13 studies met the eligibility criteria. Most were published in 2023–2024 (76.9%). Nearly half employed experimental or intervention designs (46.2%), with smaller proportions focusing on design-based studies (30.8%), theoretical or ethical analyses (15.4%), and qualitative investigations (7.7%). Mapping against SEL domains indicated stronger emphasis on self-awareness and self-management (each 30.8%), with relatively limited coverage of social awareness (15.4%), relationship skills (15.4%), and responsible decision-making (23.1%). Frequently adopted technological affordances included natural language processing, emotion recognition, and multimodal interfaces, though adult mediation and long-term developmental effects were rarely addressed. Ethical considerations were also insufficiently examined.

**Discussion:** The findings underscore the promise of AI-powered chatbots in advancing SEL during early childhood while highlighting significant gaps in empirical validation, theoretical grounding, and ethical responsibility. This review contributes a consolidated knowledge base to guide future research, pedagogical practice, and technology design, ensuring that chatbot applications in early learning environments are developmentally appropriate, ethically sound, and contextually meaningful.

## KEYWORDS

artificial intelligence, chatbot technologies, conversational agents, early childhood education, social-emotional learning (SEL), scoping review

# 1 Introduction

Artificial intelligence (AI) has evolved from a speculative concept into an embedded and influential layer within contemporary educational ecosystems. Rather than merely digitizing instructional content, AI is transforming the underlying logic of teaching and learning by enabling adaptive, interactive, and learner-centered environments powered by real-time data (Ayeni et al., 2024; Sethi and Jain, 2024). In the context of early childhood education, encompassing children from birth to age eight, this transformation holds particular developmental significance. From real-time feedback mechanisms to emotionally intelligent interfaces, AI systems increasingly act as co-mediators in the learning process, shaping children's social, cognitive, and emotional trajectories (Bozkurt, 2024; Susilo, 2024; Taşkin, 2025). This paradigm shift challenges educators and researchers to revisit foundational pedagogical assumptions while raising pressing questions about agency, trust, and the developmental appropriateness of technology-mediated interactions in early learning contexts.

Early childhood represents a formative stage in which the foundations for cognitive, social, and emotional competencies are established. Among these domains, social-emotional learning (SEL) plays a central role in fostering children's capacity to understand and express emotions, regulate behavior, develop empathy, build positive relationships, and make responsible decisions (Zins et al., 2004). The internationally recognized CASEL framework conceptualizes SEL through five interrelated competencies: self-awareness, self-management, social awareness, relationship skills, and responsible decision-making [(Collaborative for Academic, Social, and Emotional Learning (CASEL), 2020)]. Supporting SEL during the early years is not only critical for individual wellbeing and academic success but also for promoting social cohesion and long-term adaptive functioning (Blewitt et al., 2018). Traditionally, teachers and caregivers have been the primary agents in cultivating these competencies (Ulutas et al., 2021). However, the rapid expansion of AI applications in education offers new possibilities for providing SEL support that is scalable, personalized, and contextually responsive.

Within this emerging landscape, AI-powered chatbots have attracted increasing scholarly attention as tools capable of delivering emotionally attuned and interactive learning experiences. Defined as conversational agents that simulate human dialogue through natural language processing (NLP) technologies, early chatbot models were limited to basic keyword matching and rule-based responses (Hsieh, 2011). Advances in machine learning, speech processing, and contextual adaptation have since produced more sophisticated, voice-enabled systems capable of interpreting user input, maintaining contextual awareness, and responding in ways that are emotionally sensitive and developmentally meaningful (Guttormsen et al., 2011; Sari et al., 2020; Ashfaq, 2022). In early learning environments, emotionally responsive chatbots have been shown to scaffold prosocial behaviors and conversational empathy, underscoring their potential role in strengthening SEL-related competencies (Kory-Westlund and Breazeal, 2019).

Despite these promising developments, the literature on chatbot-supported SEL remains conceptually and methodologically

fragmented. Existing studies often lack consistent theoretical grounding, vary in the developmental stages they address, and predominantly focus on older children and adolescents. Critically, no scoping review to date has systematically mapped how chatbot technologies intersect with SEL in early childhood education, despite a growing body of empirical studies exploring AI-mediated learning. Our systematic search of major databases up to March 2025 confirmed the absence of such a review, indicating a clear gap in synthesizing this knowledge domain. This absence limits the field's capacity to identify best practices, anticipate ethical and pedagogical challenges, and establish evidence-based design principles for chatbot integration in SEL.

This study aims to systematically analyze research focusing on chatbot-supported SEL in early childhood, with the goal of mapping the current state of the field and offering a theoretically grounded framework to guide future investigations.

## 1.1 Conceptualizing child–chatbot interaction

Understanding the role of AI-powered chatbots in fostering social-emotional learning (SEL) in early childhood requires an integrated theoretical lens that unites developmental, relational, and technological perspectives. This study is grounded in the CASEL framework [Collaborative for Academic, Social, and Emotional Learning (CASEL) (2020)], which conceptualizes social and emotional learning (SEL) through five interrelated competencies (self-awareness, self-management, social awareness, relationship skills, and responsible decision-making) and underscores their pivotal role in fostering children's long-term academic achievement, interpersonal relationships, and emotional resilience (Zins et al., 2004). While this framework outlines the *what* and *why* of SEL, explaining *how* these competencies may emerge in child–chatbot interactions necessitates additional theoretical grounding.

From a developmental standpoint, sociocultural theory Vygotsky's provides a foundational lens for understanding how higher-order psychological functions evolve through socially mediated activity. The theory underscores the centrality of guided participation, language, and culturally situated tools in the construction of knowledge. When positioned as interactive companions embedded in a child's social environment, chatbots can operate as semiotic mediators, facilitating emotional expression, empathy, and perspective-taking. By delivering responsive dialogue and feedback, well-designed chatbot interactions can engage children within their Zone of Proximal Development (ZPD), enabling them to achieve affective and interpersonal competencies that may not emerge independently (Serholt et al., 2017).

Beyond developmental scaffolding, child–chatbot interactions unfold in an affective domain shaped by relational dynamics. The media equation theory (Reeves and Nass, 1996) posits that people unconsciously apply human social norms to interactions with computers and digital agents. Empirical research confirms that children frequently anthropomorphize chatbots, attributing to them qualities such as empathy,

trustworthiness, and companionship (Ulbricht and Simas, 2024). This anthropomorphism becomes particularly salient in emotionally charged contexts, where chatbots demonstrate turn-taking, empathetic verbal responses, or validation of the child's emotional state (Yu and Lan, 2024). These affective exchanges resonate directly with SEL's relational and emotional domains, suggesting that chatbots may not only deliver content but also co-construct meaningful social experiences.

By integrating the CASEL framework with Vygotsky's sociocultural theory and the media equation theory, this study positions child–chatbot interaction as both a cognitive-developmental and socio-affective process. Such a composite lens enables the formulation of research questions that extend beyond descriptive mapping to probe the mechanisms through which chatbot technologies can foster, mediate, or constrain SEL in early childhood contexts. Specifically, the theoretical framing supports inquiry into (a) which SEL competencies are most effectively supported through chatbot interactions, (b) how technological design features shape pedagogical outcomes, and (c) what ethical considerations arise when young children engage with chatbots as perceived social partners.

Guided by the theoretical integration of the CASEL framework, Vygotsky's sociocultural theory, and the media equation theory, this scoping review seeks to address the following questions:

1. What is the distribution of the included studies in terms of publication years, participant profiles, sample sizes, research methodologies, and keywords?
2. How is the potential of chatbots to support social-emotional learning in early childhood addressed in the literature?
3. Which technological, pedagogical, and interactional approaches are emphasized in chatbot-supported learning applications?
4. What ethical issues, debates, and proposed solutions are highlighted in the literature concerning children's interactions with chatbots?

The first question aims to reveal the structural characteristics of the field through a descriptive lens, which is common in scoping reviews. The remaining questions, however, are designed to explore the literature's conceptual depth in line with the study's theoretical framework. Questions 2 and 3 are grounded in the CASEL framework, which defines the core components of social-emotional learning and is conceptually informed by a Vygotskian perspective. The fourth question draws upon the media equation theory, emphasizing the socio-ethical implications of children perceiving chatbots as social agents. Thus, our questions are not only descriptive but also analytically grounded in relevant educational and psychosocial theories.

## 2 Methods

### 2.1 Scoping review design

This study employed a scoping review methodology to systematically map and synthesize research on the use of AI-powered chatbots to support social-emotional learning (SEL) in early childhood education. Scoping reviews are particularly well-suited for exploring emerging, conceptually diverse fields where

evidence is fragmented, as they allow for the identification of conceptual boundaries, detection of knowledge gaps, and synthesis of heterogeneous findings (Arksey and O'Malley, 2005; Levac et al., 2010; Peters et al., 2020). Given that the intersections between artificial intelligence, early childhood development, and socio-emotional pedagogy are still nascent, this approach provided the methodological flexibility and breadth required to capture relevant studies from multiple disciplines.

The review was conducted in accordance with the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) guidelines (Tricco et al., 2018) to ensure methodological transparency, replicability, and systematic reporting across all phases from search strategy formulation to data extraction and synthesis. No protocol was preregistered; however, all procedures followed the PRISMA-ScR recommended stages.

### 2.2 Data sources and eligibility criteria

Studies were selected based on predefined inclusion and exclusion criteria. Inclusion criteria required that the study:

- (a) focus on children aged 0–8 years, (b) involve chatbot-based or conversational agent interaction situated in educational contexts, and (c) address at least one domain of social-emotional learning relevant to early childhood, regardless of whether it was explicitly framed through formal SEL models.

Peer-reviewed journal articles written in English and published between January 2019 and March 2025 were eligible. The extended end date ensured inclusion of the most recent literature at the time of submission, even though no eligible 2025 studies were identified within the search period. The final database search was conducted on 15 March 2025.

Exclusion criteria included: (a) studies focusing exclusively on individuals over the age of 8, (b) purely technical or computational works without educational or developmental relevance, and (c) publications not accessible in full text or not subject to peer review.

To enhance conceptual transparency, included studies were further categorized according to their engagement with SEL. Nine studies explicitly targeted SEL domains (e.g., empathy, emotional regulation, self-awareness) as core research objectives or learning outcomes, while four studies addressed SEL implicitly without direct assessment. Both categories were retained in line with the review's aim of mapping the conceptual and practical landscape of chatbot-supported SEL in early childhood.

The five academic databases selected (Web of Science, Scopus, ERIC, ScienceDirect, and SpringerLink) were chosen for their broad coverage of education, psychology, and learning technology literature, ensuring both disciplinary diversity and methodological rigor in source retrieval.

### 2.3 Search strategy

A systematic literature search was conducted across the five selected databases using a combination of controlled vocabulary and Boolean operators to capture variations in terminology.

The search string combined terms for AI conversational agents with early childhood and SEL-related constructs. A representative example of the Boolean search strategy was as follows:

(“chatbot” OR “conversational agent” OR “AI tutor”) AND  
 (“early childhood” OR “preschool” OR “young children”) AND  
 (“social-emotional learning” OR “SEL” OR “empathy” OR  
 “emotion regulation” OR “self-awareness”)

This search strategy was iteratively refined through pilot searches to optimize sensitivity and specificity. After duplicate removal, the remaining records were screened independently by two reviewers at the title-and-abstract level. Articles meeting inclusion criteria were subjected to full-text screening. Discrepancies were resolved through consensus discussions, with a third reviewer consulted when necessary.

## 2.4 Data charting and synthesis

The data were analyzed using a structured approach that combined descriptive mapping with thematic analysis, following the PRISMA-ScR guidelines (Tricco et al., 2018) and the JBI Manual for Scoping Reviews (Peters et al., 2020). A standardized data extraction form was developed to record publication details, participant characteristics, AI agent features, study design, SEL-related domains, and key findings. This form was piloted on a subset of five studies purposively selected to represent variation in study design, participant profiles, and chatbot functionalities. Feedback from two independent reviewers during the pilot phase informed iterative refinements, including clarification of operational definitions for SEL domains, standardization of terminology for chatbot features, and the addition of fields for recording interactional context. These adjustments ensured consistency and comprehensiveness across data extraction for all included studies.

A hybrid coding strategy was employed. Deductive coding was guided by the CASEL framework’s five core competencies [Collaborative for Academic, Social, and Emotional Learning (CASEL) (2020)], while inductive coding enabled the identification of recurring, context-specific patterns in how children interacted with AI agents. Thematic analysis followed Braun and Clarke’s (2006) framework, including data familiarization, code development, theme identification, and refinement.

To ensure intercoder consistency, a subset of studies was double-coded, and any interpretive differences were resolved through discussion. The synthesized results were organized into structured tables summarizing study aims, methodological characteristics, participant profiles, and, where reported, key aspects of chatbot design. Accompanying narrative explanations illustrated key patterns and highlighted how different studies addressed core SEL domains. This reporting strategy aimed to offer a coherent overview of the reviewed evidence without overgeneralizing across diverse study contexts. A PRISMA-ScR flow diagram outlining the study selection process is presented in Figure 1.

## 3 Findings

This study examined the corpus of scholarly articles on the use of chatbots in early childhood social-emotional learning (SEL) by analyzing their distribution across publication years, research methods, participant profiles, and keywords through visual representations. Moreover, the patterns of chatbot integration into SEL processes were explored within the intersecting domains of technology, pedagogy, and ethics, thereby constructing a comprehensive map of the current research landscape in the field.

### 3.1 Distribution of studies on chatbot applications in early childhood according to various factors

The detailed characteristics of the included studies are summarized in Table 1, while the information on the publication year, research method, and participant profile of the reviewed studies is presented in Table 2.

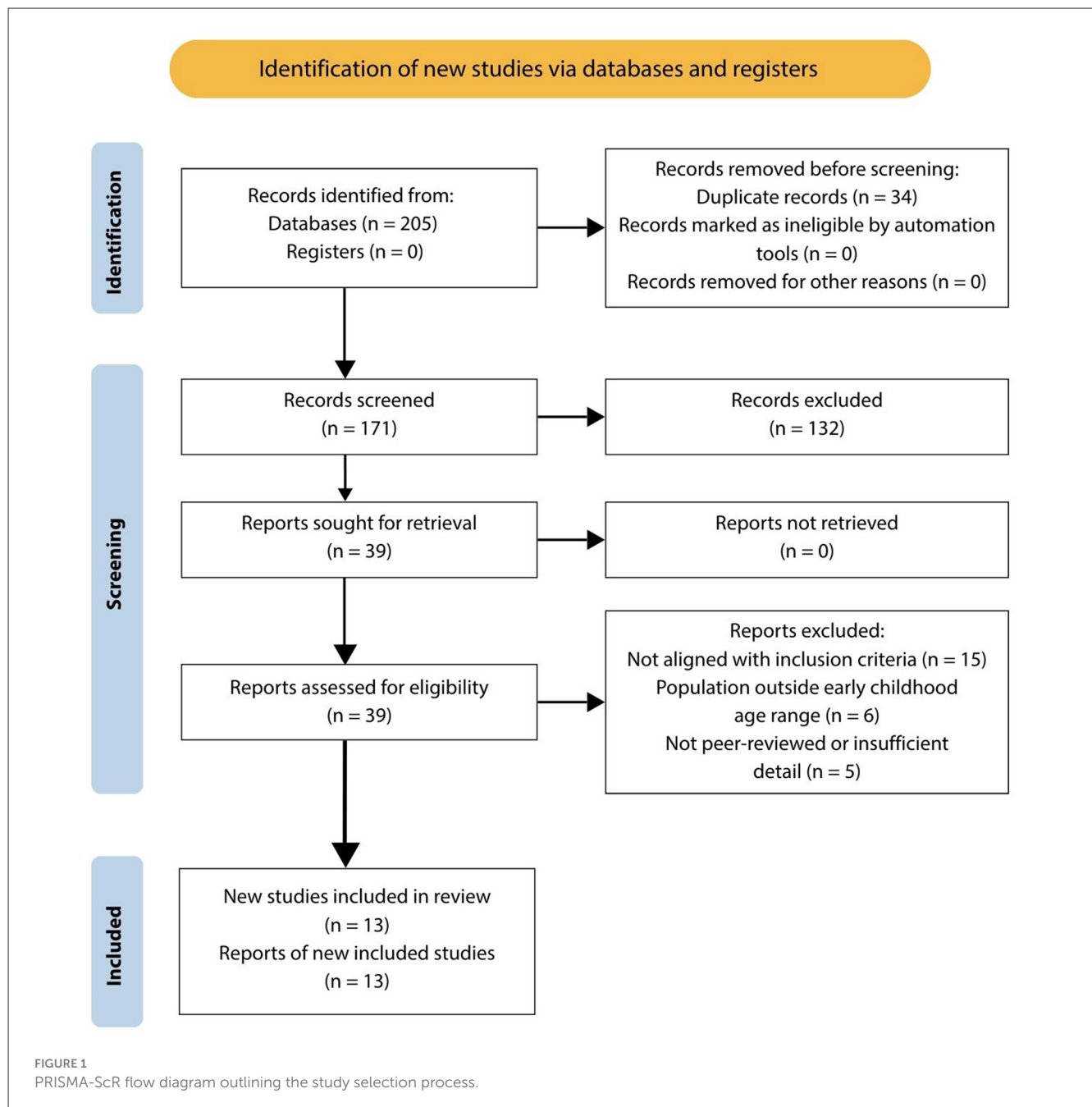
Analysis of Table 2 indicates that most studies were published in 2023 (30.8%) and 2024 (46.2%), with no eligible publications identified for 2020, 2021, or 2025. Experimental and intervention-based designs accounted for the largest share (46.2%), followed by theoretical model or technology design studies (30.8%). Purely qualitative research was relatively scarce. In terms of participant profiles, only a minority of studies (15.4%) involved direct research with children, while a considerable proportion (46.1%) did not specify participants due to their theoretical or development-oriented nature. These findings suggest that the literature remains predominantly technology-focused and outcome-oriented, with limited empirical investigation into the contextual, relational, and experiential dimensions of chatbot use in early childhood settings.

Based on the packed circle diagram constructed according to the frequency of keywords used in the articles (Figure 2), the most frequently occurring term was “Artificial Intelligence,” which appeared in 8 out of 13 articles (61.5%). The keyword “Chatbot” was used in 4 articles (30.8%). The terms “Intervention,” “Parenting,” “Autism,” and “Generative AI” were each found in 2 articles (15.4%), while all other keywords appeared in only one article (7.7%). This indicates an emphasis on tool development over the pedagogical contexts in which tools are embedded.

### 3.2 The potential of chatbots to support social-emotional learning in early childhood

Within the scope of this review, the potential of chatbots to support social and emotional learning (SEL) in early childhood is examined through the lens of the five interrelated competencies outlined in the CASEL framework, as introduced earlier. This section synthesizes empirical findings from the reviewed literature, mapping each study to the domains of self-awareness, self-management, social awareness and





empathy, relationship skills, and responsible decision-making. Table 3 provides an integrated summary of the key studies, their frequency, and the primary outcomes reported for each SEL domain.

Analysis of Table 3 shows that the domains of self-awareness and self-management were addressed most frequently, whereas relationship skills and responsible decision-making were comparatively less explored. Technological interventions have primarily been concentrated on competencies linked to the identification, expression, and regulation of emotions, with fewer initiatives explicitly targeting the more complex interpersonal and decision-making dimensions of SEL.

### 3.3 Technological and pedagogical innovations

In early childhood education, AI-powered chatbot applications possess the potential not only to deliver cognitive content but also to create personalized, emotionally attuned, and pedagogically grounded learning environments. The reviewed studies demonstrate that these technologies can be adapted to meet children's developmental needs through various innovative components. This section presents the key technological and pedagogical innovations reported in the literature, organized into thematic sub-sections.

TABLE 1 Overview of the selected studies on chatbot use in early childhood education.

Title	Authors, years	Journal	Objective	Method	Participants	Key findings
Transforming early childhood learning with AI enabled robots	<a href="#">Cao et al., 2019</a>	IEEE AI+ Intelligent Adaptive Education Summit	To explore the impact of AI-enabled robots in early childhood education and examine personalization through chatbot integration.	Technology development and theoretical framework.	Not applicable; conceptual study.	AI robots have potential to support personalized learning and emotional development, but require careful educational implementation.
User experience with a parenting chatbot micro intervention	<a href="#">Entenberg et al., 2023a</a>	Frontiers in Digital Health	To evaluate user experience with a micro-intervention chatbot aimed at teaching parents how to deliver praise to their children.	Randomized controlled trial; 89 parents received the chatbot intervention.	170 parents (89 intervention, 81 control); parents of children aged 2–11.	High completion rate (66.3%), high user satisfaction, and positive feedback; chatbots show potential for enhancing parenting skills.
AI-based chatbot micro-intervention for parents: meaningful engagement, learning, and efficacy	<a href="#">Entenberg et al., 2023b</a>	Frontiers in Psychiatry	To examine the impact of a chatbot-based micro-intervention on parental praise and attention skills.	RCT with a 15-min chatbot session.	89 parents of children aged 2–11.	Parents engaged and learned praise strategies, but no significant change in behavior or parenting self-efficacy after 24 h.
AI's empathy gap	<a href="#">Kurian, 2023</a>	Contemporary Issues in Early Childhood	To discuss ethical risks and empathy limitations of chatbots in early childhood education.	Theoretical analysis and ethical evaluation.	Not applicable.	Chatbots may misinterpret children's emotional needs and provide unpredictable or inappropriate responses. Ethical guidelines are essential.
No, Alexa, No!	<a href="#">Kurian, 2024</a>	AI and Ethics	To analyze the risks of empathy gaps and data privacy in large language models for child safety.	Theoretical analysis and ethical discussion.	Not applicable.	AI chatbots may compromise children's privacy; transparent data policies and ethical oversight are necessary.
From keyboard to chatbot	<a href="#">Lee and Xiong, 2024</a>	ACM	To create a chatbot-based instructional system using LLMs for teaching programming to children aged 4–9.	Conceptual model and technology development.	Not specified; target group is young children.	LLMs in natural language programming can support children's computational and cognitive skill development.
Incorporating humanoid artificial intelligence (AI) robots	<a href="#">Lee et al., 2024</a>	Early Childhood Education Journal	To propose a framework for integrating humanoid AI robots in early childhood education.	Conceptual model and educational framework proposal.	Not applicable.	Humanoid robots may enhance cognitive and socio-emotional development but must be integrated cautiously.
AI in early childhood education in Ghana	<a href="#">Mohammed, 2023</a>	American Journal of Education and Technology	To explore the feasibility of AI use in Ghanaian early childhood settings based on educators' perspectives.	Qualitative study with interviews and focus groups.	8 teachers from four early childhood institutions in Ghana.	Educators saw potential in AI for personalization and development but expressed concerns about privacy and ethical issues.

(Continued)

TABLE 1 (Continued)

Title	Authors, years	Journal	Objective	Method	Participants	Key findings
Chatbot for children assistance	<a href="#">Patil et al., 2022</a>	IJRASET	To develop an AI chatbot for children aged 3–7 to make learning interactive and fun.	Application development using AI and ML for voice and text interaction.	Not specified; designed for young children.	Chatbot supported daily learning activities, facilitated interaction via voice/text, and created an engaging learning environment.
MOLHEM	<a href="#">Sweidan et al., 2024</a>	Education and Information Technologies	To develop an avatar-based chatbot app for enhancing social and cognitive skills in Arab children with ASD.	Mobile app development and expert review.	150 stakeholders including parents, specialists, and teachers.	Positive effects on social skills; recommendations for adding multiplayer support and more features in future versions.
Employing a voice-based emotion-recognition function in a social chatbot	<a href="#">Tsai et al., 2019</a>	Lecture Notes in Computer Science	To develop a voice-based emotion recognition chatbot for supporting SEL in preschoolers.	Experimental study integrating voice/emotion recognition with guided conversation scenarios.	30 preschool children.	Improved emotional recognition and expression in children; innovative use of AI for emotional monitoring.
EmoEden	<a href="#">Tang et al., 2024</a>	CHI Conference on Human Factors in Computing Systems	To design a generative AI tool for emotional learning in children with high-functioning autism.	22-day user study integrating LLMs and text-to-image models.	6 children with high-functioning autism.	EmoEden was effective in enhancing emotional recognition and expression in autistic children.
StoryBuddy	<a href="#">Zhang et al., 2022</a>	CHI Conference on Human Factors in Computing Systems	To develop a human-AI collaborative chatbot for interactive storytelling with flexible parental involvement.	Needs analysis, participatory design, and user testing.	12 parent-child pairs.	StoryBuddy enhanced narrative skills and supported co-engagement in storytelling between parents and children.

3.3.1 Natural language processing and personalization

Natural Language Processing (NLP) enables chatbots to interpret children’s language use, analyse prior interactions, and generate prompts that align with the situational and developmental context. This technological capacity underpins personalisation in early learning environments, allowing educators and designers to tailor experiences to individual needs. Three studies in particular (Patil et al., 2022; Lee and Xiong, 2024; Cao et al., 2019) illustrate how NLP-enabled systems can analyse children’s responses, detect recurring errors, and deliver scaffolding suited to developmental needs. In practice, Patil et al. (2022) developed a voice- and text-enabled chatbot that fostered children’s active participation in daily learning activities, enhancing both engagement and enjoyment. Lee and Xiong (2024) implemented an NLP-based instructional system for programming that identified recurring misconceptions and supported conceptual understanding. Similarly, Cao et al. (2019) proposed that personalized approaches may yield both cognitive and socio-emotional benefits. Collectively, these findings demonstrate that NLP-based chatbots not only increase engagement and conceptual grasp but also contribute to socio-emotional growth, underscoring their potential to create learning environments that are both developmentally appropriate and pedagogically intentional.

3.3.2 Learning through gamification and storytelling

Gamification and storytelling represent pedagogical strategies that cultivate active participation and foster emotional resonance with learning content. Sweidan et al. (2024) demonstrated that an avatar-based chatbot incorporating reward points and interactive challenges strengthened children’s social competencies and cognitive engagement by sustaining motivation and attention. Similarly, Zhang et al. (2022) introduced *StoryBuddy*, a co-creative storytelling chatbot, and reported that joint story creation with parents was associated with improvements in children’s narrative structures and emotional vocabulary. Lee and Xiong (2024) suggested that active involvement in storylines may enhance social interaction and deepen emotional bonds, though evidence remains preliminary. Taken together, these studies show that gamified chatbot applications nurture problem-solving skills and sustained engagement, while story-based designs expand empathy, emotional expression, and narrative competence through interactive participation.

3.3.3 Emotion recognition and adaptive learning

Emotion recognition systems assess children’s affective states using verbal and non-verbal indicators, enabling chatbots to adapt interaction strategies dynamically. A total of four studies illustrate this potential. Tsai et al. (2019) found that voice-based emotion recognition combined with guided conversational scenarios supported preschoolers in identifying and articulating emotions. Tang et al. (2024) reported that combining emotion detection with generative AI tools fostered emotional awareness in children with high-functioning autism. Similarly, Zhang et al. (2022) observed that adaptive responses tailored to children’s emotional states

TABLE 2 Distribution of the reviewed studies by year, method, and participant profile.

Year (n, %)	Research method (n, %)	Participant profile (n, %)
2019: 1 (7.7%)	Experimental/intervention study: 6 (46.2%)	Parents: 3 (23.1%)
2022: 2 (15.4%)	Theoretical model development/technology design: 4 (30.8%)	Children: 2 (15.4%)
2023: 4 (30.8%)	Theoretical analysis/ethical evaluation: 2 (15.4%)	Teachers: 1 (7.7%)
2024: 6 (46.2%)	Qualitative study: 1 (7.7%)	Parent-child: 1 (7.7%)
		Not specified (theoretical/development): 6 (46.1%)

Percentages are calculated within the subgroup of each variable.

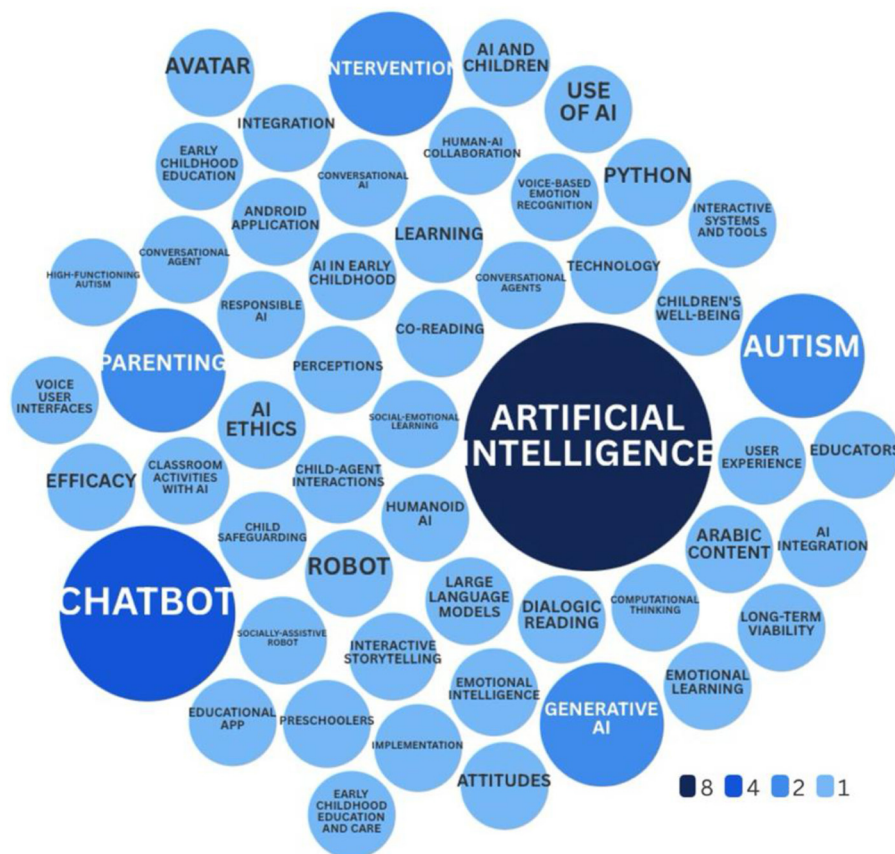
were linked with greater engagement, empathy, and emotional regulation. In a different socio-cultural context, Mohammed (2023) highlighted how emotion recognition systems sustained motivation and learning persistence. Collectively, these findings suggest that emotion recognition technologies can accurately identify children’s emotional states and, when paired with adaptive learning mechanisms, promote sustained engagement and improved regulation of emotions.

3.3.4 Multimodal and embodied interfaces

Multimodal and embodied interfaces enrich child–chatbot interactions by combining multiple sensory modalities with physical embodiment. Four studies in particular highlight this potential. Tang et al. (2024) developed a system that integrated text-to-image generation to reinforce children’s emotional comprehension. Cao et al. (2019) proposed a robotics–chatbot integration model in which embodied interaction created more personalized learning experiences. Sweidan et al. (2024) demonstrated that avatar-based multimodal features encouraged children’s willingness to participate socially and sustain dialogue. In addition, Lee et al. (2024) suggested that humanoid robots, when carefully designed for early learning contexts, have the potential to enhance both cognitive and socio-emotional development. Taken together, these findings indicate that multimodal and embodied designs, whether through voice, facial expressions, gestures, or robotic embodiment, can strengthen children’s sense of social presence, deepen emotional engagement, and enrich the personalisation of learning experiences.

Overall, the reviewed studies illustrate a growing yet uneven body of evidence on the integration of chatbots into early childhood social-emotional learning. While technological innovations such as natural language processing, gamification, emotion recognition, and multimodal interfaces demonstrate potential to enhance engagement, emotional awareness, and personalized learning, the literature remains limited in its direct engagement with children and in its exploration of contextual and relational dynamics.





**FIGURE 2**  
Distribution of keywords used in the articles.

TABLE 3 Summary of the findings reported in the reviewed studies by SEL domains.

SEL domain	Key studies	<i>n</i> (studies)	% of total studies	Summary of findings
Self-awareness	Tsai et al., 2019; Zhang et al., 2022; Tang et al., 2024; Cao et al., 2019	4	30.77%	AI-based systems enhanced children's ability to recognize and express emotions. Story-based applications facilitated emotional awareness.
Self-management	Entenberg et al., 2023a,b; Sweidan et al., 2024; Tang et al., 2024	4	30.77%	Chatbot guidance supported emotional regulation and the development of context-appropriate responses.
Social awareness and empathy	Zhang et al., 2022; Sweidan et al., 2024	2	15.38%	Story-based chatbots encouraged perspective-taking and empathy in peer and character interactions.
Relationship skills	Lee and Xiong, 2024; Sweidan et al., 2024	2	15.38%	Structured dialogues promoted social interaction skills and cooperative behaviors.
Responsible decision-making	Patil et al., 2022; Zhang et al., 2022; Mohammed, 2023	3	23.08%	Scenario-based chatbots provided opportunities for practicing responsible decision-making in simulated contexts.

## 4 Discussion

This scoping review synthesizes an emerging yet increasingly sophisticated body of research on AI-powered chatbots in early childhood education, with particular attention to their role in fostering social-emotional learning (SEL). Across 13 peer-reviewed studies published between 2019 and 2025, our

analysis reveals both notable promise and persistent limitations. While the field recognizes the pedagogical potential of chatbot technologies, current applications remain uneven in their theoretical grounding, methodological rigor, and attention to the full spectrum of SEL competencies. Viewed through the CASEL framework [Collaborative for Academic, Social, and Emotional Learning (CASEL) (2020)], the existing literature

appears to prioritize competencies that are technically easier to operationalize, while more relational and ethically complex domains remain underexplored.

## 4.1 Thematic trends and inclusivity in literature

The majority of the studies reviewed suggest that chatbot technologies are most frequently associated with supporting observable and structurally definable social-emotional competencies, such as self-awareness, emotion regulation, and empathy (Tang et al., 2024; Zhang et al., 2022). The prominence of these themes may be attributed to the relative ease with which technology can be integrated into such domains. For example, emotion recognition algorithms can classify children's affective responses through voice and text-based inputs, enabling the delivery of personalized and adaptive feedback (Tsai et al., 2019; Cao et al., 2019).

In contrast, more socially embedded and cognitively complex skills, such as relationship building and responsible decision-making, were found to be less frequently addressed. This underrepresentation may reflect current technological limitations in supporting these competencies in authentic, context-rich interactions. Furthermore, existing literature emphasizes that these domains are pedagogically constrained when attempted without the mediation of adult guidance (Kurian, 2023; Mohammed, 2023).

From the perspective of a developmentally integrated SEL framework, this thematic imbalance underscores a significant research gap. It suggests that while certain aspects of SEL may be more amenable to technological mediation, others still require robust human interaction and ethically grounded instructional design to be effectively nurtured.

## 4.2 The challenge of pedagogical alignment in technological innovation

Recent research indicates that chatbot technologies, through advanced modules such as natural language processing (NLP), emotion recognition, and adaptive learning, offer children increasingly personalized learning experiences (Babin and Chauhan, 2024; Lee and Xiong, 2024). These systems can generate real-time responses tailored to children's verbal output, attention levels, and emotional reactions, representing significant potential in individualized education. However, there is still ongoing debate over how effectively this technological capacity is being integrated into pedagogical principles within educational settings. While many studies emphasize the systems' cognitive processing capabilities, pedagogical design considerations often remain secondary or only marginally addressed.

Although child-centered strategies such as gamification or storytelling are occasionally integrated, their impact on affective learning has rarely been evaluated systematically (Sweidan et al., 2024; Zhang et al., 2022).

The development of social and emotional competencies in early childhood takes place not only through individual interaction

but within context-rich learning environments shaped by adult mediation. Xu et al. (2025) report that chatbot interactions guided by teachers have a positive effect on children's social participation and emotional development. Similarly, Kurian (2024) argues that chatbots can become effective learning tools only when integrated within hybrid models that include active teacher involvement. In the same study, however, the author notes that children sometimes engage with these technologies independently and without supervision, pointing to the need for safety-focused design principles that are as robust as their pedagogical frameworks.

It is clear that research should focus not only on the presence of guidance but also on its nature, duration, frequency, and contextual influence. Yet, current literature provides only limited discussion of these pedagogical variables, and they are not consistently operationalized in ways that allow systematic measurement. This limitation reduces our understanding of how chatbots can be pedagogically integrated and points to the need for more applied research.

Future studies should explore how chatbot technologies can be synchronized with the role of teachers, what strategies educators use to guide these systems, and how these interactions can be optimized to support children's social-emotional learning outcomes. Pedagogical alignment is not simply about merging education with technology; it entails a complex process of reconstruction informed by developmental psychology, educational philosophy, and sociocultural context. For chatbot systems to make a meaningful contribution to SEL, what is needed is not only technological competence but also a holistic and ethically grounded pedagogical design.

## 4.3 Ethical risks, security, and regulatory frameworks

Although addressed only briefly in most studies, ethical considerations, particularly those related to data protection and algorithmic bias, are gaining increased attention. Personalized chatbot systems often process sensitive child data, including emotional expressions, voice recordings, and interaction histories. These practices raise important questions about how such data are collected, stored, and shared. While frameworks such as the General Data Protection Regulation (European Parliament and Council of the European Union, 2016) in the European Union and the Children's Online Privacy Protection Act (United States Congress, 1998) in the United States establish legal standards for protecting children's privacy, explicit engagement with these policies is rare in the reviewed literature (Kurian, 2024; Piispanen et al., 2024).

Equally concerning is the potential for reinforcing cultural biases and gender stereotypes embedded in AI training data (Lee and Xiong, 2024). These risks are particularly critical in early childhood, a developmental period in which children are actively constructing their social identities. Without careful design and deliberate bias mitigation, AI systems may inadvertently shape children's understanding of themselves and others in ways that perpetuate inequities. For this reason, technological accuracy must be accompanied by a strong commitment to

cultural responsiveness, ethical accountability, and transparency in system design.

## 4.4 Risks to social interaction and emotional attachment

Alongside their potential to support social-emotional learning, chatbots also raise concerns about the replacement of human relationships, an issue increasingly debated in recent research. Studies involving avatar-based and humanoid robot interactions have documented instances in which children form emotional bonds with these systems, potentially diminishing their motivation to engage in real-world social relationships (Sweidan et al., 2024). Kurian (2023) found that some children referred to chatbot characters as “friends” and demonstrated emotional projection toward them, blurring the line between artificial and human relational dynamics.

However, social-emotional learning cannot be sustained solely through digital means. Without the scaffolding of human interaction and the contextual richness of real-life social environments, children risk experiencing developmental gaps in their emotional and social competencies. Supporting this concern, Xu et al. (2025) demonstrated that when chatbot interactions were mediated by teacher guidance, children’s social participation increased and affective skill development was significantly enhanced. These findings strongly suggest that chatbots should be positioned as complementary tools, not as substitutes for authentic human relationships in educational contexts.

## 5 Limitations

This scoping review was conducted to thematically map the literature on AI-based chatbot applications and their potential contribution to social-emotional learning (SEL) in early childhood. While the study offers valuable insights, several methodological and conceptual limitations should be noted to inform future research efforts.

First, the review includes a relatively small number of studies ( $n = 13$ ), most of which were conducted with limited sample sizes and short-term pilot implementations. Although this provides an initial overview of the field, it restricts the generalizability of the findings and limits the possibility of assessing long-term developmental impacts, particularly in relation to complex and context-dependent SEL processes.

Second, the scoping review approach allowed for a broad exploration of the literature but did not involve a systematic assessment of methodological quality. Elements such as sample adequacy, validity, reliability, and the rigor of data analysis were not examined. While this is consistent with the nature of scoping reviews, it also narrows the interpretive depth of the findings and highlights the need for more robust empirical studies in the future.

A further limitation concerns the limited attention given to pedagogical variables, particularly adult mediation. Teacher and parent guidance plays a critical role in shaping children’s

learning with technology, yet many studies failed to systematically incorporate or evaluate these factors. This omission weakens our understanding of how chatbot systems function in authentic educational contexts.

Taken together, these limitations suggest that future research should move beyond assessing technical performance alone. A more holistic and context-sensitive research paradigm is needed—one that integrates pedagogical structuring, cultural responsiveness, ethical safeguards, and the systematic role of adult facilitation in early learning environments.

## 6 Conclusion

This scoping review mapped the current body of peer-reviewed literature examining the use of chatbot technologies in early childhood education, with a particular focus on their potential to support social-emotional learning (SEL). By synthesizing findings from 13 studies, the review identified emerging patterns, thematic concentrations, and notable research gaps. Across the literature, technological affordances such as natural language processing, emotion recognition, and adaptive interaction design were frequently linked to gains in certain SEL domains, particularly self-awareness and self-management. However, competencies such as relationship skills and responsible decision-making were addressed less consistently, indicating an imbalance in how the full breadth of SEL is integrated into chatbot-based interventions.

The analysis also revealed that much of the existing research prioritizes technical feasibility over pedagogical integration, with limited systematic attention to adult mediation, cultural adaptation, and ethical safeguards. While studies demonstrated the capacity of chatbots to deliver individualized learning experiences, their effectiveness appears highly dependent on the presence and quality of human facilitation, as well as the broader educational and cultural contexts in which they are implemented.

In keeping with the exploratory nature of a scoping review, these findings should be interpreted as a descriptive mapping rather than an evaluation of effectiveness. The synthesis highlights areas where research has converged, where it remains sparse, and where methodological refinement is needed. Advancing this field will require studies that move beyond proof-of-concept toward designs that are pedagogically grounded, ethically responsible, and culturally responsive. Ultimately, chatbot technologies should be positioned as complementary tools within holistic learning ecosystems, contributing to but not replacing the interpersonal and contextual foundations of social-emotional development in early childhood.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Author contributions

BÖ: Conceptualization, Writing – original draft, Supervision, Writing – review & editing. SS: Methodology, Writing – review & editing, Data curation, Formal analysis, Writing – original draft. CB: Methodology, Visualization, Data curation, Writing – review & editing, Writing – original draft.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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