

Enhancing Socio-Emotional Skills in Children with Autism through AI-Powered Serious Games: A Narrative Review

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Abstract—This narrative review explores the integration of Artificial Intelligence (AI) and Serious Games (SGs) as a novel, interdisciplinary approach to fostering socio-emotional skills in children with Autism Spectrum Disorder (ASD). As ASD is characterized by persistent challenges in emotional understanding, social communication, and behavioral regulation, there is a growing need for interventions that are both effective and personalized. SGs provide structured, interactive environments where children can practice skills such as emotion recognition, joint attention, and empathy in a safe and motivating way. When augmented with AI, these games offer real-time feedback, dynamic personalization, and adaptive learning experiences tailored to individual cognitive and emotional profiles. This review synthesizes recent empirical evidence on AI-powered SGs targeting socio-emotional development in children with ASD. It examines the design strategies, targeted competencies, and evaluation methods used across current literature. The integration of SGs and AI is positioned as a promising and scalable tool to promote autonomy, emotional well-being, and social inclusion in neurodiverse children.

Index Terms—Serious Games, Artificial Intelligence, Autism Spectrum Disorder, Socio-emotional skills, Emotion Recognition, Personalized Intervention

I. INTRODUCTION

AUTISM Spectrum Disorder (ASD) is a complex, life-long neurodevelopmental condition characterized by persistent difficulties in social communication and interaction, along with restricted and repetitive patterns of behavior, interests, or activities [1]. With the growing global prevalence of ASD, there is an urgent need for effective, individualized interventions that address the unique profiles and evolving needs of autistic children and their families. Among the most critical domains for intervention is the development of socio-

emotional competencies, which are foundational for overall well-being, meaningful relationships, and successful participation in school and community life. This need is supported by developmental frameworks such as Bandura's Social Learning Theory [2], which emphasizes learning through observation and interaction, and cognitive-behavioral models that highlight the role of emotional awareness and regulation in adaptive functioning. These perspectives provide a theoretical basis for designing digital tools that scaffold emotional development and promote meaningful social engagement. Difficulties in emotional understanding, behavioral regulation, and interpersonal engagement often lead to heightened anxiety, social withdrawal, and limited opportunities for inclusion [3]. In response to these challenges, Serious Games (SGs) have emerged as innovative tools in therapeutic and educational contexts. Designed with specific learning or clinical objectives, SGs provide structured, immersive environments where children with ASD can safely practice and generalize socio-emotional skills. These game-based interventions leverage the affinity many autistic children have for digital and rule-based systems, increasing engagement and retention while reducing the unpredictability of real-life interactions [4]. At the same time, Artificial Intelligence (AI) has emerged as a powerful tool for personalizing and optimizing interventions. Through machine learning, natural language processing, and real-time feedback systems, AI can monitor behavior, assess progress, and adapt content to individual needs [5]. When combined with SGs, AI enhances their adaptability, responsiveness, and effectiveness, providing tailored support that evolves with the user [6]. Together, SGs and AI offer a promising framework for delivering targeted, engaging, and personalized socio-emotional interventions for children with

ASD. This narrative review aims to explore key trends and thematic insights into the integration of Serious Games and Artificial Intelligence in the promotion of socio-emotional development in children with ASD. It examines key applications, benefits, and evaluation strategies, and addresses the challenges, ethical considerations, and future directions in this rapidly evolving field [7]. Building on the author's previous research on AI-driven autism interventions and VR-based serious games for adolescents [6, 7], the present work narrows its focus to the use of AI-powered SGs to enhance socio-emotional competencies in children with ASD. The aim is to synthesize current evidence and identify future directions for research, development, and implementation of these promising tools. This review is guided by the following questions: (1) How are Serious Games enhanced by AI used to foster socio-emotional development in children with ASD? (2) What evidence exists regarding their effectiveness, design strategies, and implementation challenges? These questions inform the structure and scope of the present synthesis.

II. BACKGROUND: SERIOUS GAMES AND AUTISM

An expanding body of research highlights the diverse applications of SGs in supporting children with ASD. These tools have been used to target a wide range of skills, including social communication, turn-taking, empathy, and collaboration. Rather than aiming for exhaustive coverage, this section provides a thematic overview of key developments in the use of Serious Games for children with ASD, as reported in selected studies and literature reviews. Recent developments in reinforcement learning systems for healthcare support have shown how AI can provide adaptive decision-making in real time, adjusting treatment pathways based on patient interaction patterns [10]. This work illustrates how reinforcement learning frameworks, although not ASD-specific, can be repurposed for responsive intervention delivery in SG contexts. Such mechanisms could be leveraged in SGs to optimize emotional feedback loops and behavioral reinforcement in children with ASD.

Many SGs leverage immersive technologies such as virtual reality to simulate realistic environments where children can safely practice social interactions. Other games are designed to support emotion recognition and regulation by helping users identify facial expressions, vocal cues, and contextual emotional indicators [11]. SGs have also been applied to areas like attention control, executive functioning, and language development, including vocabulary building and vocalization. In addition to core developmental skills, SGs have been shown to support learning in academic and functional life domains. Some games teach numeracy, literacy, and problem-solving skills, while others focus on everyday tasks such as navigating public transportation, understanding health and safety practices, or applying basic first aid. These experiences not only promote cognitive development but also enhance independence and self-confidence in real-world situations [12].

SGs offer multiple advantages for children with ASD. Their structured, predictable, and customizable nature aligns

well with the preferences of many autistic learners, helping to reduce anxiety and sensory overload. They provide opportunities to engage in repeated practice at an individualized pace, with feedback tailored to specific learning profiles. The interactive nature of SGs increases motivation and engagement, which are crucial for the success of therapeutic and educational programs. Moreover, the use of multisensory feedback and realistic simulations supports memory, self-regulation, and emotional awareness, encouraging the transfer of learned skills to everyday settings [13]. While SGs provide a structured and engaging medium for practicing skills, AI introduces the capability to personalize and dynamically adapt these interventions. The next section explores how AI technologies contribute to the broader landscape of autism interventions, laying the groundwork for their integration within game-based contexts.

III. BACKGROUND: ARTIFICIAL INTELLIGENCE IN INTERVENTIONS FOR AUTISM

AI has found a wide range of applications in tools and interventions developed to support children with ASD. One of its most impactful uses is in the personalization of learning experiences through machine learning algorithms and adaptive platforms that provide real-time feedback. These systems can monitor user behavior, track progress, and dynamically adjust content, making learning more responsive and individualized [14].

AI is also used to support the development of social skills. It powers interactive systems such as virtual agents, conversational chatbots, and social robots that simulate real-life interactions. These tools support turn-taking, nonverbal cue recognition, and social problem-solving in controlled environments [15].

In communication, AI enhances Augmentative and Alternative Communication (AAC) tools by incorporating features like predictive text, intelligent voice recognition, and adaptive vocabulary suggestions. These capabilities help users with limited verbal communication express themselves more efficiently, and systems improve over time by learning from usage patterns [16].

Emotional understanding is another key domain where AI contributes significantly. Intelligent systems can detect and interpret facial expressions, vocal tone, and body language using computer vision and affective computing. Children receive immediate feedback from avatars or virtual tutors, helping them improve emotion recognition and regulation [17].

AI also supports the analysis of social behavior through natural language processing and multimodal data interpretation. These systems assess user engagement, attention, and response patterns, providing valuable insights for clinicians and educators. In some cases, AI can offer autonomous support during learning sessions without direct human supervision.

Another important application is in early screening and diagnosis. By analyzing data such as gaze patterns, movement, vocalizations, and neuroimaging, AI systems can help detect

early signs of ASD, improving the timeliness and accuracy of assessments [18].

Overall, AI enables highly adaptive and scalable interventions that align with the diverse learning needs of children with ASD. When integrated into virtual or gamified environments, AI increases engagement, promotes independent learning, and supports the acquisition of social, emotional, and cognitive skills. Its ability to process large datasets and refine its responses over time makes it a valuable tool in both educational and therapeutic contexts [19]. This section highlights recurring applications of AI identified across various studies and conceptual papers, illustrating the breadth of its contribution to autism interventions.

IV. METHOD

A computerized search was carried out using the Scopus database to identify studies on the integration of SGs and AI aimed at supporting socio-emotional development in children with ASD. The search was limited to publications in English, published between 2014 and 2024, and focused on intervention-based studies involving SGs designed to improve emotional and social functioning in children with ASD. The following search string was used in the TITLE-ABS-KEY field: “serious games” AND “autism” AND “emotions”. This query returned thirty-one records. After an initial screening of titles and abstracts, articles that did not meet the preliminary inclusion criteria were excluded. These included studies focusing solely on physical rehabilitation, motor coordination, sensory processing, or diagnostic methods without the use of game-based or AI-enhanced interventions. From this initial set, six studies were identified as directly meeting the eligibility criteria for detailed narrative synthesis. These included five empirical interventions and one systematic review, all focusing on the explicit integration of Serious Games with Artificial Intelligence to promote socio-emotional development in children with ASD.

The six included studies were:

1. Zirkus Empathico 2.0 [20]: RCT – multiplayer SG with adaptive feedback for emotion recognition and empathy;
2. EMOCASH [21]: pilot study – intelligent agent-based multiplayer game using the ASPECTS™ model;
3. JeStiMule [22]: pre-post study – multimodal facial expression training game with adaptive feedback;
4. Game-Based Social Interaction Platform [23]: pilot study – integrated eye-tracking with emotion recognition tasks;
5. Interactive game using physiological sensors [24]: pilot study – real-time biofeedback for emotional state classification;
6. Emotion Detectives [25]: quasi-experimental ABA design – SG with adaptive learning for emotion discrimination.

Eligible articles addressed key domains such as emotion recognition, emotional regulation, empathy, joint attention, and social interaction, and employed AI features such as real-time feedback, gaze tracking, physiological sensing, and

adaptive personalization algorithms. For example, the Game-Based Social Interaction Platform [23] utilized real-time eye-tracking combined with facial emotion recognition tasks to assess user engagement and emotional responses.

V. NARRATIVE REVIEW

This narrative review aims to synthesize and critically compare recent literature on the use of AI-powered SGs to foster socio-emotional development in children with ASD. The originality of this contribution lies in: (a) the focus on SGs specifically enhanced by AI components such as adaptive feedback, emotion recognition, and personalization systems; and (b) the thematic analysis of socio-emotional outcomes such as empathy, joint attention, emotion regulation, and prosocial behavior.

A total of twenty-two studies were identified through the initial screening. Among these, six empirical interventions were retained for in-depth synthesis, based on their integration of AI-driven components and their targeted impact on socio-emotional development in ASD. The remaining studies were used to support background discussion on broader trends, implementation challenges, and design principles.

Zirkus Empathico 2.0 [20], a bilingual mobile serious game tested in Germany and Pakistan, significantly improved emotional awareness and empathy in children with ASD after an 8-week randomized controlled trial. Notably, participants were able to apply learned emotional skills in real-world contexts, showing potential for generalization beyond the digital environment.

Similarly, EMOCASH [21], a virtual agent-based multiplayer game, was designed to teach both financial literacy and emotion recognition within a 3D virtual shop. The game, tailored to Egyptian children with ASD using the ASPECTS™ design index, demonstrated high usability and educational impact by facilitating real-life skill transfer in a socially simulated environment. Another line of research explored emotion recognition via multimodal feedback systems.

The game JeStiMule [22], focused on improving facial expression recognition, showed significant pre-post improvements in accuracy on standardized emotion tasks in a sample of Moroccan children with ASD. These outcomes highlight the importance of integrating multimodal feedback, repetitive training, and adaptive interfaces based on functioning level.

A fourth study [23] the Game-Based Social Interaction Platform, integrated real-time eye-tracking with facial emotion recognition tasks. Reduced fixation on positive expressions was interpreted as a digital biomarker of engagement.

An additional study [24] used physiological sensors within an interactive game to assess and classify emotional states, laying the groundwork for future emotionally responsive game-based interventions.

Finally, the Emotion Detectives [25] game demonstrated improvements in emotion discrimination and self-regulation in children with neurodevelopmental conditions, including ASD, with gains maintained at a one-month follow-up.

From a design perspective, the reviewed literature emphasizes the relevance of co-design practices involving both

autistic users and key stakeholders such as parents and educators. Games developed with Tangible User Interfaces (TUIs) [26] proved particularly effective in maintaining attention and facilitating emotional understanding. Despite encouraging outcomes, the field still suffers from limited clinical validation, small sample sizes, and short follow-up periods. Furthermore, most reviewed games were developed for high-functioning children with ASD, revealing a need for more inclusive designs. Overall, the integration of AI in SGs provides a scalable and adaptable framework for delivering engaging, personalized, and evidence-informed socio-emotional interventions in autistic populations.

VI. DISCUSSION

This discussion integrates both the main empirical findings and broader implications of the reviewed studies. It begins by synthesizing key socio-emotional outcomes across interventions, then explores design considerations, methodological limitations, and opportunities for future research in the field of AI-powered Serious Games for children with ASD.

The reviewed studies collectively illuminate promising directions in the development and application of SGs and immersive technologies to support socio-emotional learning in children with ASD. While the integration of such tools has not yet reached full methodological maturity, emerging patterns suggest tangible benefits for emotion recognition, behavioral regulation, and engagement in children with ASD.

Recent evidence underscores the pivotal role of immersive environments in modulating emotional activation and improving performance in emotion recognition tasks. The pilot study utilizing Unreal Engine 4 [27], although conducted on neurotypical adults, demonstrated heightened emotional engagement in 3D environments compared to traditional settings. These findings are especially relevant for ASD interventions, where attention and motivation are often reduced. It is plausible that immersive graphics and interactive feedback may scaffold attentional focus and facilitate deeper emotional processing in children with ASD - a hypothesis that warrants further empirical validation in clinical populations.

Games leveraging multisensory tools—such as real-time eye-tracking, physiological sensors, and spatialized audio—demonstrated potential for broader accessibility and improved user engagement.

The adaptive capabilities of SGs, powered by AI, are increasingly recognized as essential to their efficacy. Games such as JeStiMule [22] and Emotion Detectives [25] integrated feedback mechanisms that responded dynamically to user behavior, allowing for personalized pacing and reinforcement. These features align well with the cognitive and emotional heterogeneity characteristic of ASD. Intervention outcomes from these studies demonstrated not only significant improvements in targeted emotion discrimination tasks but also observable behavioral gains in naturalistic settings, suggesting generalization beyond the digital context.

For instance, in the Emotion Detectives study [25], the system adjusted the difficulty and type of emotion recognition

tasks in real time based on the child's performance, offering immediate visual and auditory reinforcement when correct responses were detected. This dynamic feedback loop helped maintain engagement and reinforce emotional learning in a personalized manner.

Personalization remains a critical factor in intervention success. The variability in cognitive profiles among children with ASD - particularly between high- and low-functioning individuals - necessitates differentiated user interfaces and multimodal content. For example, the JeStiMule [22] study revealed that children with high-functioning autism significantly outperformed their lower-functioning peers in emotion recognition tasks, highlighting the need for adaptable systems. Multisensory feedback tools, including eye-tracking (as seen in the Game-Based Social Interaction Platform [23]), spatialized audio, and physiological sensors, may enhance accessibility and foster engagement across a broader segment of the autism spectrum.

Beyond empirical outcomes, several design and usability insights were noted.

A recurring theme is the divergence between user motivation and therapeutic intention. Studies grounded in user-centered frameworks, such as the one referencing Whyte et al.'s model [28], showed that autistic youth prioritize engaging, visually rich gameplay, while professionals emphasize generalizable skill acquisition. Bridging this divide requires participatory design approaches that incorporate the lived experiences and preferences of children with ASD, ensuring both usability and therapeutic relevance.

Despite encouraging findings, methodological limitations remain. Sample sizes across studies were often small, and long-term assessments were rarely conducted. Additionally, there is a notable gap regarding the use of AI to dynamically adapt emotional feedback and narrative progression within SGs.

In practical terms, an emotionally attuned system would use multimodal inputs - such as facial expression analysis, vocal tone monitoring, and physiological sensors - to detect a child's emotional state and adapt gameplay accordingly. For example, if signs of frustration or disengagement are detected, the system could simplify tasks, slow down interactions, or introduce calming stimuli to re-engage the user.

Nevertheless, the convergence of AI, adaptive learning environments, and game-based delivery represents a compelling frontier for inclusive and scalable ASD interventions.

VII. FUTURE DIRECTIONS AND RESEARCH GAPS

Despite the growing interest and positive initial findings regarding SGs and AI for children with ASD, emerging themes and conceptual gaps identified across the literature suggest several promising areas for future exploration.

One promising future direction involves the development of more advanced AI algorithms capable of deeper personalization and nuanced real-time adaptation to a child's learning style, emotional state, and progress. Such systems could provide finely tuned interventions that evolve continuously based

on user interaction [29]. Another emerging area is the creation of hybrid AI-human learning models, where AI supports but does not replace human instruction or therapy. Hybrid AI-human models have been tested in platforms like Woebot [30] or Replika [31], where automated responses are supported by clinician supervision or feedback. These models may combine the scalability of digital tools with the irreplaceable relational and contextual insight of human facilitators. Related to this is the need to leverage multimodal data inputs - such as text, audio, facial expressions, gesture, and biosignals - to design more natural and emotionally attuned learning experiences [32].

Designing SGs that address sensory sensitivities and support imaginative play is another crucial area for development. These capabilities could significantly expand the emotional and behavioral range of digital interventions, particularly for children who have trouble with unstructured or abstract tasks. Furthermore, the field would benefit from interdisciplinary design frameworks that bring together educators, clinicians, game developers, families, and neurodiverse individuals to co-create content. This participatory approach would ensure that SGs reflect real-world needs and diverse lived experiences [33].

Advanced time-series prediction models, such as GLinear [34], offer new possibilities for decoding physiological and behavioral signals in real time. GLinear and similar architectures have been proposed for modeling arousal and engagement in real time using physiological data streams [34]. These architectures could enhance SG responsiveness by enabling more accurate modeling of attention, arousal, and engagement patterns.

Generative AI, which allows for the creation of dynamic narratives, characters, and interactive environments based on user input, represents another exciting frontier. Generative AI systems, such as GPT-based narrative engines, can dynamically adjust storylines and dialogue based on user preferences or detected emotions. By generating personalized stories or scenarios, such systems may enhance engagement, emotional learning, and long-term retention. On the research side, longitudinal studies are essential to evaluate the sustained impact of AI-integrated SGs on socio-emotional development, academic outcomes, and real-life functioning. Additional studies should examine the role of social interactions within multiplayer SGs, particularly how these experiences transfer to offline settings [35].

There are several critical gaps that must be addressed to strengthen the field. These include the limited number of long-term and ecologically valid studies, and the lack of research examining how cultural and socioeconomic factors affect the success and accessibility of SG and AI interventions. Furthermore, there is a pressing need for more inclusive sampling to represent the full diversity of the autism spectrum, as well as greater focus on underexplored domains such as emotional regulation in high-stress or unpredictable contexts. Another persistent issue is the generalization gap - that is, the

challenge of ensuring that skills practiced within SGs translate meaningfully to everyday environments. Lastly, there remains an absence of standardized frameworks for evaluating and comparing different AI-enhanced SG interventions, which hinders both replication and broader implementation [36].

Emerging metric-driven approaches designed for the recognition of hazardous or high-stakes situations offer promising frameworks for modeling stress responses and predicting behavioral escalations [37]. These could inform the design of emotionally aware SGs capable of anticipating distress and dynamically modulating difficulty or content.

Future research must address these shortcomings through rigorous, long-term, and multisite studies. There is also a need to explore emerging AI applications and to develop standardized, reliable outcome measures. Doing so will help establish stronger evidence base and improve the design and delivery of effective, inclusive, and sustainable digital interventions for children with ASD.

VIII. CONCLUSION

The integration of SGs and AI represents a rapidly growing and highly promising frontier in the promotion of socio-emotional skills among children with ASD. This combined approach leverages the immersive, interactive nature of game-based learning and the adaptive, data-driven capabilities of AI to deliver interventions that are not only engaging but also finely tailored to the unique and heterogeneous profiles of autistic learners [38].

SGs provide structured, low-risk environments where children can repeatedly practice and reinforce critical skills such as emotion recognition, turn-taking, and social communication. These environments benefit learners who experience anxiety or sensory overload in real-life contexts. AI further enhances these games by enabling dynamic personalization - adjusting content and difficulty in real time based on the child's behavioral patterns, emotional cues, and performance data. When combined, SGs and AI support a wide array of socio-emotional competencies, including self-regulation, empathy, joint attention, and behavioral flexibility. As such, this integrated approach serves as a powerful complement to traditional therapeutic and educational interventions [39].

Research to date has yielded encouraging results, with numerous studies documenting measurable improvements in specific target areas following the use of AI-enhanced SGs. However, the field is still evolving, and there remains considerable variation in study methodologies, sample sizes, and assessment tools. These inconsistencies limit the ability to draw firm conclusions about generalizability and long-term effectiveness. A stronger evidence base is needed to guide the design, implementation, and evaluation of these tools across diverse populations and real-world settings. In particular, future studies should address the generalization gap - ensuring that skills learned in digital contexts transfer meaningfully to everyday social environments. Future research must focus on longitudinal studies involving larger and

more diverse participant groups to better capture the full spectrum of ASD and the contextual factors that influence intervention outcomes [40].

At the same time, the field must prioritize transparency and fairness in algorithm design to avoid reinforcing existing disparities or excluding vulnerable users. By balancing innovation with ethical responsibility, AI-powered Serious Games can evolve into truly inclusive and impactful tools for supporting the emotional well-being and social inclusion of children with ASD.

Despite its potential, this approach also presents a number of critical challenges. Key concerns include the need for inclusive, sensory-accessible design; transparent and ethical use of personal data; algorithmic fairness; and equitable access across cultural and socio-economic backgrounds. Additionally, developers and practitioners must guard against the risk of over-reliance on technology, ensuring that these tools supplement, rather than replace, essential human interactions and relationships.

To ensure sustainable progress, interdisciplinary collaboration will be essential - bringing together children with ASD, caregivers, educators, clinicians, AI developers, and game designers throughout the research and development process [41].

Looking forward, the field should adopt a participatory and interdisciplinary framework that brings together children with ASD, families, educators, clinicians, designers, and researchers. Such collaboration is vital to creating tools that are relevant, user-centered, and grounded in real-life experiences. Advances in generative AI and hybrid human-AI learning models offer exciting possibilities for deepening engagement, promoting emotional insight, and crafting personalized narratives that resonate with each child's developmental needs. Furthermore, the integration of multimodal data - such as facial expressions, speech, biosignals, and gaze - can pave the way for more emotionally responsive and adaptive learning environments [42]. In parallel, future systems must adopt transparent, explainable AI protocols and ensure that personalization algorithms do not inadvertently reinforce cognitive or socio-economic disparities in access or engagement. To fully realize their potential, AI-powered SGs must be embedded in broader clinical frameworks and supported by policies that ensure ethical deployment, accessibility, and cross-sector integration in health and education systems.

This work is positioned as a conceptual and narrative synthesis aimed at fostering discussion on the integration of AI and Serious Games for autism intervention. As such, it contributes to ongoing dialogue in the interdisciplinary community and aligns with the goals of conferences like FedCSIS.

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