








A Systematic Review of Gamified Augmented Reality Interventions to Enhance Engagement for Children with Autism Spectrum Disorder

Angel Gabriel Meela^{1,2} , Deogratias Shidende³ , Bonny Mgawe¹ 
Judith Leo¹  and Sabine Moebs³ 

¹Nelson Mandela African Institution of Science and Technology, Box 447, Arusha, Tanzania

²Institute of Accountancy Arusha, Box 2798, Arusha, Tanzania
ameela@nm-aist.ac.tz (Corresponding Author)

³Baden-Württemberg Cooperative State University (DHBW), Marienstraße 20
89518 Heidenheim, Germany

Abstract. Autism Spectrum Disorder (ASD) offers a significant challenge in social communication, sustained attention, and motivation, often limiting the ability of children to engage in activities essential for their development. This systematic literature review investigates the potential of combining gamification and Augmented Reality (AR) to address these challenges. Using the PRISMA framework across four major academic databases, 24 articles were selected for a comprehensive analysis to address six research questions on effectiveness, developmental impact, gamification elements, methodological rigor, accessibility, and caregiver involvement.

Findings indicate that gamified AR interventions are largely effective in enhancing engagement among children with ASD, positively influencing developmental domains such as social skills, cognitive function, and attention modulation. The effectiveness is amplified by the synergy between AR's immersive nature and gamification elements like rewards, progress, and narrative. Methodologically, the field is characterized by diverse research designs, predominantly Mixed Methods, but with a scarcity of rigorous Randomized Controlled Trials. Furthermore, a critical lack of holistic accessibility prioritization was identified, with crucial features such as caregiver-configurable settings, text-to-speech/speech-to-text capabilities, and offline progress tracking largely overlooked. Caregiver involvement was limited to the implementation phase rather than the initial co-design process.

The review confirms the potential of gamified AR as a powerful intervention modality. To advance the field, future research must prioritize rigorous methodological designs, incorporate a holistic approach to accessibility, and actively engage caregivers in co-design. These steps are essential for developing interventions that are not only engaging but also scientifically validated, inclusive, and practical for real-world application.

Keywords: Augmented Reality, Gamification, Autism Spectrum Disorder, Engagement, Systematic Literature Review.

1 Introduction

Autism Spectrum Disorder (ASD) affects over 1% of the global pediatric population and is a complex neurodevelopmental condition characterised by persistent challenges in social communication and interaction, together with restricted and repetitive patterns of behaviour [1, 2]. A substantial proportion of children with ASD present with co-occurring conditions; estimates suggest that nearly 40% experience associated disabilities, including non-verbal communication and hearing impairments [3, 4]. The rising prevalence underscores the significant impact of ASD on children's development, learning, and everyday functioning, creating a sustained demand for early, effective, and engaging interventions that support skill development and quality of life outcomes [5].

Conventional intervention approaches, while valuable, often face limitations related to maintaining long-term engagement, generalizing learned skills to real-world contexts, and accommodating the pronounced heterogeneity of the ASD population [6]. These challenges have driven growing interest in technology-enhanced interventions that offer adaptive, motivating, and contextually rich learning experiences.

In this context, augmented reality (AR) and gamification have emerged as promising approaches. AR blends digital content with real-world environments, enabling interactive, situated, and multimodal learning experiences that can enhance attention and engagement [7]. Gamification, the incorporation of game-design elements into non-game contexts, has been shown to positively influence motivation, persistence, and engagement among children with ASD [8]. By incorporating structured challenges, goal-oriented tasks, and immediate feedback, gamification aligns well with cognitive and motivational profiles commonly observed in ASD, particularly in addressing difficulties related to intrinsic motivation and sustained attention [9]. When combined, AR and gamification offer complementary affordances that can support engagement, skill acquisition, and context-aware learning.

Despite a growing body of empirical work on AR-based or gamified interventions for children with ASD, existing reviews tend to examine these approaches in isolation or address technology-assisted interventions at a broad level [10-12]. Prior reviews have largely focused on AR for social skills or learning support, or on gamification in special education contexts, often without systematically analysing engagement mechanisms, theoretical grounding, or evaluation practices [13, 14]. Moreover, limited attention has been given to how gamification elements are operationalised within AR environments, how engagement is measured across heterogeneous study designs, or how accessibility and caregiver involvement are incorporated into intervention design and deployment. Consequently, an integrative synthesis connecting design features, engagement mechanisms, methodological rigor, and implementation considerations in gamified AR interventions (GARIs) for ASD remains lacking.

This systematic literature review addresses this gap by synthesising and critically appraising empirical evidence on GARIs for ASD children, with a particular emphasis on engagement and related developmental outcomes. Specifically, the review contributes by: (i) comparatively analysing gamification elements and AR affordances across interventions; (ii) examining research designs, assessment tools, and evaluation metrics

used to measure engagement and developmental impact; (iii) identifying reported accessibility features and inclusivity considerations; and (iv) analysing the role of caregivers in the design, implementation, and use of these interventions. Through this integrative lens, the review aims to identify prevailing trends, highlight methodological and practical gaps, and provide evidence-informed guidance for forthcoming study and intervention development.

Accordingly, the review reports the following research questions: What is the effectiveness of GARIs in enhancing engagement among children with ASD (RQ1)? Which developmental domains, such as attention modulation, cognitive skill acquisition, and interactive learning, are positively influenced by these interventions (RQ2)? What gamification elements are commonly integrated into AR interventions for children with ASD, and how do they affect user engagement (RQ3)? What research designs, assessment tools, and evaluation metrics have been employed to measure the impact of GARIs (RQ4)? What accessibility features are reported in existing study regarding GARIs for ASD children (RQ5)? To what extent and in what capacities are caregivers involved in the design and implementation of GARIs for ASD children (RQ6)?

The remainder of this paper is organised as follows. Section 2 explains the methodology of the systematic review. Section 3 present the synthesised results aligned with the research questions. Section 4 discusses the findings in relation to theory and practice, outlines implications and limitations, and Section 5 wind up the paper with future directions of research.

2 Methodology

This study was conducted in harmony with the PRISMA guidelines [15] to synthesise and critically appraise empirical evidence on GARIs aimed at enhancing engagement among children with ASD. The SLR followed the PRISMA phases: identification, screening, eligibility, and inclusion (**Fig. 1**).

2.1 Search Strategy and Study Selection

A systematic search was conducted across IEEE Xplore, ACM Digital Library, PubMed, and Scopus, selected for their relevance to technological, educational, and health-related research [16, 17]. A structured query was as follows: TITLE ("augmented reality" OR "AR" OR "mixed reality") AND ABSTRACT ((autism OR asd OR neurodevelop* OR cognitive) AND gam*) AND ALL (engag* OR interact* OR attention OR "skill acquisition" OR effect* OR evaluat* OR therapy OR educat*). The search was limited to peer-reviewed articles published between January 2015 and July 2025, reflecting the maturation of mobile AR and gamified intervention research [18]. The final search was completed on 2 July 2025, yielding 362 records, of which 248 unique studies remained after duplicate removal.

Titles and abstracts were screened by two independent reviewers against predefined inclusion and exclusion criteria (Table 1). Disagreements were resolved through discussion, with consultation of a third reviewer when required. Following screening, 46

studies progressed to review of the full text. Full-text resulted in the exclusion of 22 studies after assessment, primarily due to insufficient engagement reporting or absence of gamification elements, leaving 24 studies for final inclusion (Appendix I).

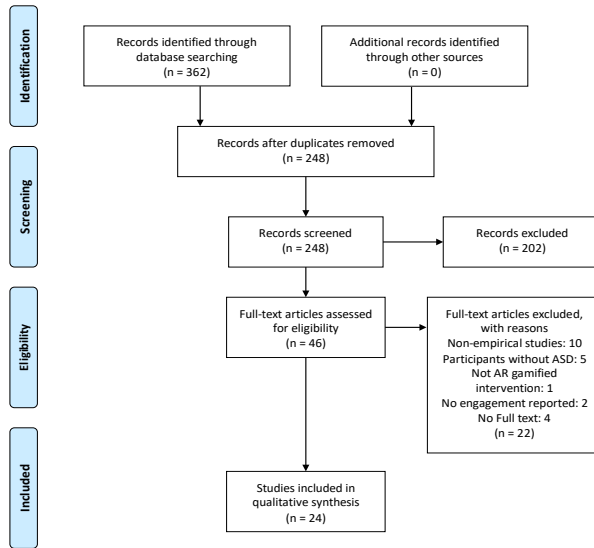


Fig. 1. PRISMA 2020 flow diagram for the systematic literature review

Table 1. Inclusion and Exclusion criteria

Inclusion Criteria	Exclusion Criteria
i. Peer-reviewed empirical studies (2015 – 2025).	i. Non-gamified AR or non-AR studies
ii. Studies involving children diagnosed with ASD.	ii. Non-ASD/ADHD Children Populations.
iii. Combined AR & gamification interventions.	iii. Theoretical, editorial, or review articles.
iv. Quantitative or qualitative engagement outcomes	iv. Non-English Publications.

2.2 Data Extraction and Quality Appraisal

Data were extracted using a structured extraction form, which captured bibliographic information, participant characteristics, intervention features (AR type, gamification elements, duration, setting), engagement and developmental outcomes, research design and evaluation methods, accessibility features, and caregiver involvement. This ensured consistency and comparative synthesis aligned with the research questions.

Methodological quality was appraised using the Mixed Methods Appraisal Tool (MMAT) [19], which supports consistent evaluation across qualitative, quantitative, and mixed-methods designs. In line with MMAT guidance, study quality was interpreted descriptively rather than numerically and considered during result interpretation, with findings from methodologically weaker studies treated cautiously. Overall, the included studies demonstrated moderate to adequate quality, though variability in engagement measurement and limited longitudinal evaluation were observed.

2.3 Theoretical Framework and Operationalisation

Self-Determination Theory (SDT) and Flow Theory (FT) were adopted as interpretive lenses to support theory-informed synthesis of engagement-related findings [20, 21]. During analysis, intervention features and outcomes were mapped to SDT's core needs: autonomy, competence, and relatedness, by examining design characteristics such as user choice, adaptive difficulty, feedback, and social interaction.

Flow Theory was operationalised by analysing the presence of clear goals, immediate feedback, challenge–skill balance, and immersive interaction, including AR affordances such as spatial anchoring and multimodal feedback. Theoretical coding was applied analytically rather than as an inclusion criterion; studies were not required to explicitly reference SDT or FT. These frameworks were used to structure comparative interpretation, identify recurring engagement mechanisms, and highlight theoretical gaps and opportunities for more explicit theory-driven design and evaluation in future GARIs for children with ASD.

3 Results

This SLR synthesised evidence from 24 empirical studies examining GARIs for children with ASD (Appendix I). The studies were published between 2015 and 2025, with a pronounced increase after 2020, reflecting advances in mobile AR platforms and game-based learning technologies (**Fig. 2**). Research output was geographically concentrated in East Asia, particularly China and Taiwan, accounting for approximately 63% of the studies, while other regions were sparsely represented (**Fig. 3**), indicating limited geographical diversity in the evidence base.

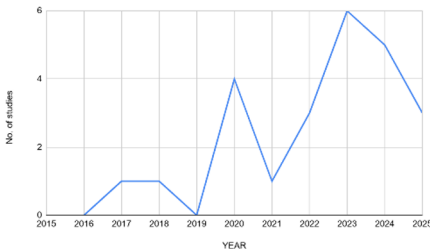


Fig. 2. Publication year of reviewed articles

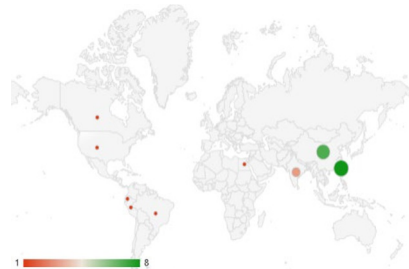


Fig. 3. Geographical distribution of reviewed articles

Immersion level correlates closely with device type and interaction complexity (**Fig. 4**). Low-immersion handhelds focus on touch and marker scanning for structured learning [22-24]. Medium-immersion systems enable gesture and voice interaction for motor and social practice [25, 26]. High-immersion head-mounted devices support advanced hand and gaze tracking for social tasks, albeit with higher sensory demands [27-29].

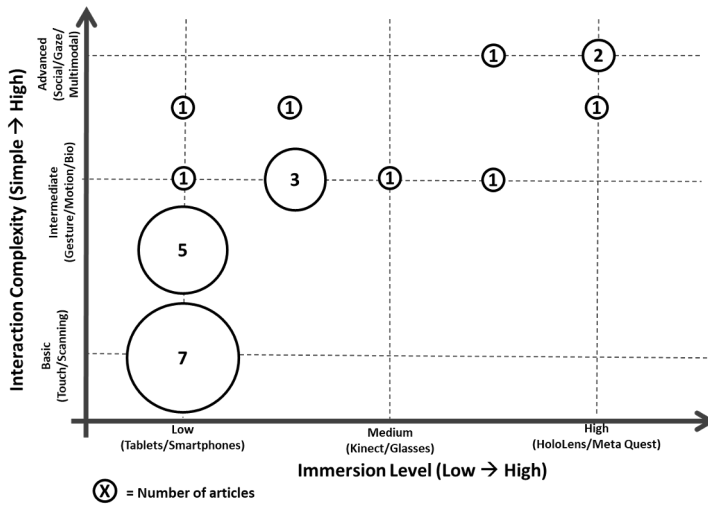


Fig. 4. Map of immersion level vs. interaction complexity used in reviewed articles

3.1 Effectiveness of Gamified AR interventions (RQ1)

GARIs consistently demonstrated positive effects on engagement among children with ASD (Fig. 5). Engagement gains were most pronounced in behavioural domains, including sustained attention, task focus, and reduced off-task behaviour [30-32]. Social engagement outcomes, such as joint attention and reciprocal interaction with peers or therapists, were also frequently reported, particularly in collaborative or socially mediated interventions [23, 27, 33]. Affective and motivational engagement, including enjoyment and willingness to participate, was reported less consistently but remained evident across multiple studies [34, 35].

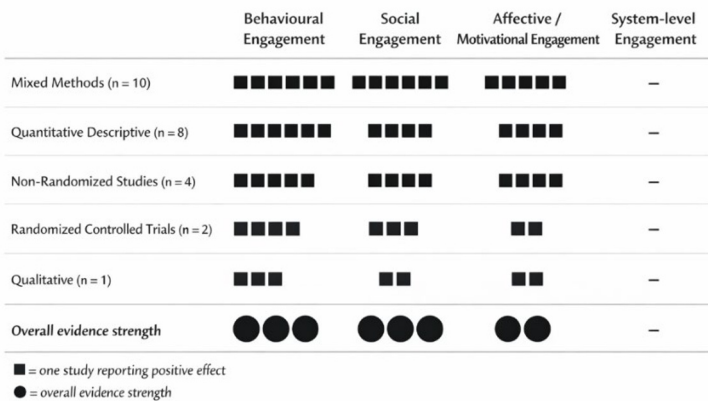


Fig. 5. Evidence map of engagement outcomes organised by study design and outcome domain.

The overall evidence strength is strong for behavioural and social engagement and moderate for affective–motivational engagement (**Fig. 5**). Behavioural and social gains were observed across mixed-methods, non-randomised, and randomised designs [32, 36], whereas affective outcomes were more often inferred from caregiver- or therapist-reported measures. Objective system-level engagement metrics, such as interaction logs or time-on-task telemetry, were rarely reported.

Overall, the SLR indicates that GARIs represent a promising approach for enhancing engagement in children with ASD, while also highlighting the need for standardised, multi-modal engagement measures to improve comparability and evidential robustness.

3.2 Developmental Outcomes Influenced (RQ2)

GARIs were associated with improvements across multiple developmental domains, although effects varied in magnitude and consistency (**Fig. 6**). The most consistently reported gains were observed in attention, engagement, and motivation, followed by social and communication skills and cognitive and executive functions. These domains appeared particularly responsive to interventions combining immersive AR affordances with structured, goal-oriented activities, suggesting engagement as a key enabling mechanism.

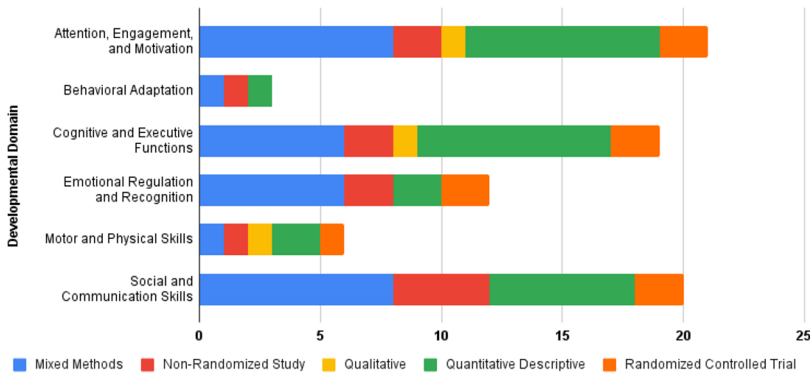


Fig. 6. The influence of gamified augmented reality interventions on developmental outcomes

Improvements in cognitive and executive functioning, including concentration, reaction time, and task performance, were reported across diverse device types and study designs [35, 37, 38]. Similarly, social and communication outcomes, such as emotion recognition and reciprocal interaction, were frequently reported in socially situated or role-playing AR scenarios [32, 39]. A smaller subset of studies reported reductions in challenging or repetitive behaviours, indicating potential benefits for behavioural regulation [26, 40].

However, developmental effects were not uniform across domains. Behavioural adaptation outcomes were underrepresented and showed mixed or non-significant results in some studies [22, 40], and a small number of interventions reported null effects for

attention or social communication [25, 41]. These findings highlight the influence of intervention design, duration, and participant heterogeneity, including ASD severity. Overall, the evidence suggests that while GARIs show broad developmental promise, their effectiveness is domain-specific, underscoring the importance of targeted designs aligned with clearly defined developmental goals.

3.3 Gamification Elements Integrated into AR Interventions (RQ3)

Across the reviewed interventions, gamification design choices were highly convergent, with a strong emphasis on elements supporting immediate engagement (**Fig. 7**). Rewards and feedback mechanisms, followed by visual and interactive elements, were most frequently implemented across clinical, educational, and home-based settings. These elements were typically realised through points, visual cues, animations, and immediate performance feedback, reflecting their central role in reinforcing task engagement and performance for children with ASD.

In contrast, narrative and immersive structures and challenge–mastery progression was less commonly incorporated. When present, these elements were embedded in role-playing scenarios, social stories, or progressively structured tasks, supporting contextualised skill practice and potential generalisation. Their lower prevalence suggests a design focus on short-term engagement and task completion rather than longer-term motivational trajectories or adaptive skill development. Overall, the distribution of gamification elements reflects a pragmatic design orientation that favours perceptual salience and immediate reinforcement, likely influenced by the need to balance engagement benefits with cognitive and sensory load in children with ASD.

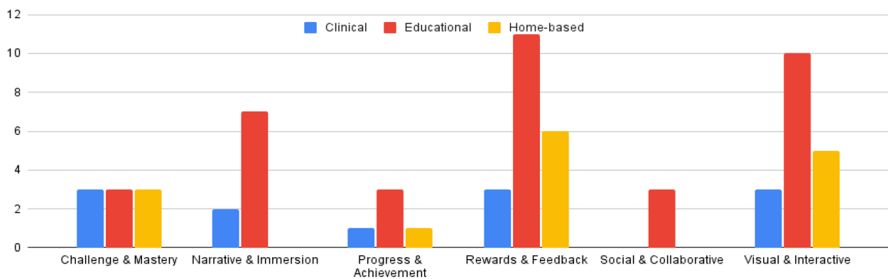


Fig. 7. Gamification elements integrated into AR interventions for children with ASD

3.4 Methodological Rigor (RQ4)

The methodological landscape of GARIs for children with ASD is characterised by substantial heterogeneity, with mixed-methods and quantitative descriptive designs dominating (**Fig. 8**). Randomised controlled trials (RCTs) remained rare, limiting the strength of causal inferences regarding intervention effectiveness. Across designs, behavioural observation and performance-based metrics, including task accuracy,

completion time, attention duration, and observed social behaviours, were most frequently employed [22, 35, 39].

Subjective and proxy measures, such as parent interviews, teacher checklists, and motivation questionnaires, were also widely used, often relying on study-specific or non-standardised instruments [28, 41]. In contrast, physiological and sensor-based measures (e.g., eye tracking, EEG, fNIRS, motion capture) were used in a smaller subset of studies and were more commonly associated with methodologically rigorous designs, including RCTs and advanced mixed-methods approaches [29, 38, 42]. While multimodal assessment reflects the complexity of engagement and development in ASD, the predominance of custom measures, small samples, and short intervention durations constrains comparability and limits conclusions regarding long-term effects.

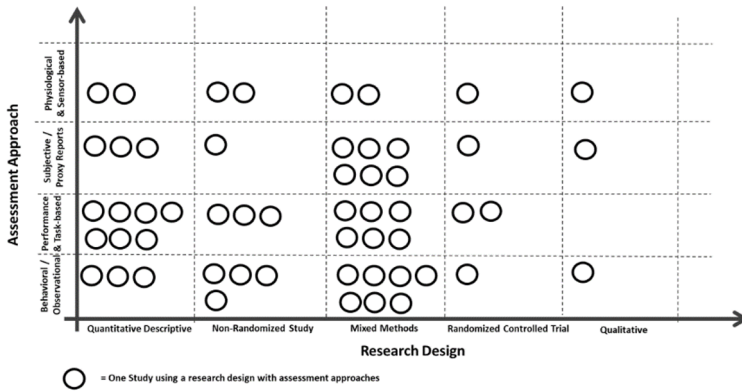


Fig. 8. Mapping of research design and assessment approaches

3.5 Accessibility Features of Gamified AR Interventions (RQ5)

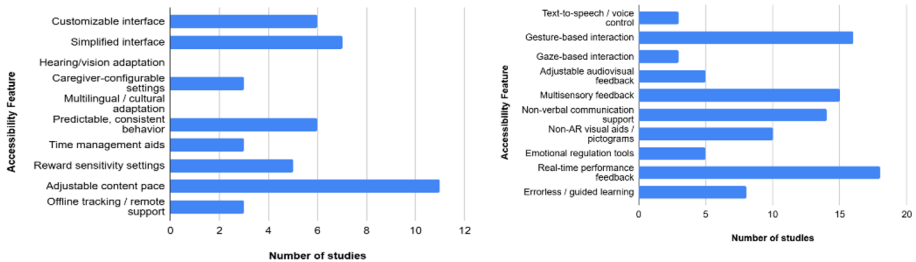


Fig. 9. Accessibility features reported in the studies

Analysis of reported accessibility features reveals a selective and uneven approach to accessibility (Fig. 9). Most interventions prioritized interaction-level adaptations, including real-time feedback, gesture-based interaction, multi-sensory cues, and non-

verbal communication support, reflecting their perceived importance for accommodating engagement and diverse communication profiles in children with ASD [25, 39].

In contrast, features supporting personalisation, continuity of use, and caregiver mediation were markedly underrepresented. Caregiver-configurable settings, Text-to-Speech or Speech-to-Text capabilities, offline progress tracking, and remote caregiver support were rarely reported [29, 31]. Moreover, explicit adaptations for hearing or vision impairments and multilingual or culturally adaptive content were largely absent. Collectively, these patterns indicate that accessibility is often treated as an implicit by-product of engagement-focused design rather than as a holistic design objective spanning users, contexts, and stakeholders.

3.6 Caregivers' Involvement in the Design and Implementation (RQ6)

Caregiver involvement exhibited a clear implementation–design divide (**Fig. 10**). Across all 24 studies, caregivers, primarily teachers, followed by parents and therapists, played a central role during implementation, facilitating sessions, monitoring engagement, and integrating AR tools into educational or therapeutic routines [32, 41].

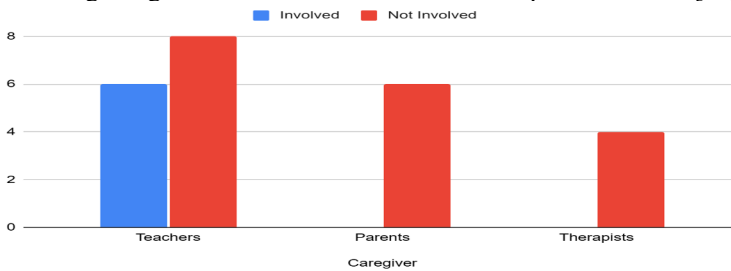


Fig. 10. Caregiver Involvement in the co-design of Gamified AR interventions

By contrast, caregiver participation in co-design and early-stage development was rare. Most studies adopted top-down design approaches, with intervention concepts and mechanics defined primarily by researchers or developers. Only a small subset explicitly reported involving teachers in co-design activities, such as refining task structure or classroom integration strategies [22, 36]. This limited adoption of participatory design represents a missed opportunity, as caregivers possess critical contextual knowledge regarding children's needs, practical constraints, and long-term sustainability. The observed imbalance may also help explain the limited reporting of configurable accessibility features and deployment support identified in RQ5.

3.7 Conceptual Framework

Based on RQ1–RQ6, **Fig. 11** presents a conceptual framework integrating design characteristics, engagement mechanisms, developmental outcomes, and evaluation practices in GARIs for ASD. It illustrates how technological and interaction design choices shape behavioural, social, and affective–motivational engagement. Engagement is a central link between design features and developmental outcomes like

attention regulation, social communication, and cognitive functioning. Evaluation and evidence strength are incorporated as a foundational layer, indicating how assessment approaches and research design rigor condition the confidence of reported effects.

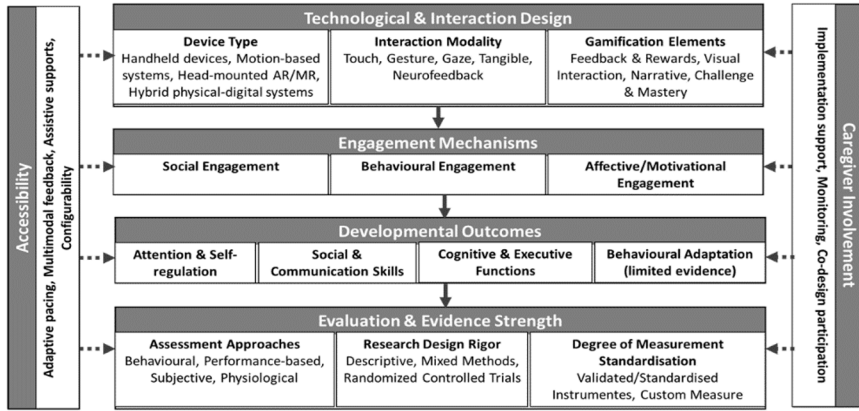


Fig. 11. Conceptual framework synthesising design, engagement, outcomes, and evaluation in gamified AR interventions for Autism Spectrum Disorder children

Accessibility and caregiver involvement are cross-cutting dimensions influencing all intervention stages. While the framework reflects current emphases on interaction-level accessibility and caregiver implementation, it also highlights research gaps in configurability and participatory design. Ultimately, the framework helps understand current practices and guide more inclusive, methodologically robust future research.

4 Discussion

4.1 Synthesis of Findings and Theoretical Interpretation

This SLR shows that GARIs consistently enhance engagement among children with ASD, benefiting attention, social communication, and cognitive functioning. Effects were strongest for behavioural and social engagement, while affective–motivational and behavioural adaptation outcomes were more variable. Importantly, engagement emerges not merely as an outcome but as a mechanistic driver supporting developmental change, aligning with findings across RQ1–RQ2.

These patterns can be interpreted through SDT and FT, which together explain the recurrent effectiveness of specific design features. From an SDT perspective, effective interventions support competence through immediate feedback and achievable challenges, autonomy through self-paced and interactive tasks, and relatedness through socially situated activities and caregiver-mediated interaction [21]. FT further explains sustained engagement in designs that balance challenge and skill, provide clear goals, and deliver immediate feedback within immersive contexts [20]. AR’s capacity to externalise abstract concepts into spatially anchored, interactive representations appears

particularly beneficial for children with ASD, who often benefit from concrete and visually supported learning experiences [43].

At the same time, the SLR reveals systemic gaps that constrain scalability and long-term impact. Accessibility is largely limited to interaction-level adaptations, caregiver involvement is predominantly implementation-focused rather than participatory, and evaluation practices remain weakly standardised. Together, these gaps suggest a research emphasis on short-term engagement gains over inclusion, sustainability, and generalisability.

4.2 Implications for Design, Evaluation, and Implementation

The findings support several design principles for GARIs targeting children with ASD. Competence-supportive design, including adaptive difficulty, explicit goals, and interpretable feedback, should be prioritised, as these features consistently align with behavioural and social engagement. Autonomy-supportive mechanisms, such as adjustable pacing and multiple interaction modalities, are essential for accommodating heterogeneity in sensory preferences, cognitive profiles, and ASD severity. Relatedness-supportive design, including collaborative tasks, social narratives, and caregiver-mediated interaction, appears critical for social and communication outcomes.

At the same time, the review shows that accessibility is often treated as an implicit by-product of engagement-focused design rather than as an explicit objective. Future interventions should embed accessibility as a core design layer, incorporating caregiver-configurable settings, assistive supports (e.g., TTS/STT), sensory modulation options, and culturally or linguistically adaptive content. These features are central to sustaining autonomy and competence across diverse user needs and preventing disengagement due to sensory or communication barriers.

The synthesis highlights a need for greater convergence in assessment practices. While multimodal evaluation is a strength of the field, reliance on custom, non-standardised measures limits comparability and cumulative evidence building. Future studies should adopt a minimum common outcome set that combines behavioural engagement indicators, social engagement measures, and validated proxy or self-report instruments where appropriate. Integrating objective system-level data (e.g., interaction logs, time-on-task) with behavioural and caregiver-reported measures would further reduce reporting bias. The scarcity of longitudinal follow-up remains a critical limitation, constraining conclusions about skill generalisation and durability.

While caregivers are central to intervention delivery, they remain peripheral to the design process. Future research should emphasize co-design and provide structured training for parents and teachers across school, clinic, and home settings. Finally, addressing equity-related barriers, such as device availability and offline functionality, is critical for the adoption of these tools beyond controlled research environments. [44].

4.3 Limitations of the Study

This review is subject to several limitations. Restriction to selected databases and English-language publications may have excluded relevant studies. Heterogeneity in

intervention types, durations, and outcome measures precluded meta-analysis, although it enabled broad synthesis. Finally, potential publication bias and methodological limitations within individual studies, such as small samples and limited use of control groups, underscore the need for more rigorous future research.

5 Conclusion and Future Directions

This SLR review demonstrates that GARIs are a promising and increasingly mature approach for supporting engagement and development in children with ASD. The evidence indicates consistent benefits for behavioural and social engagement and positive, though more variable, effects on cognitive and emotional outcomes. The review's primary contribution lies in synthesising how design choices, engagement mechanisms, accessibility, caregiver involvement, and methodological rigor interact to shape intervention effectiveness.

To advance the field, future research should prioritise: (1) Stronger causal evidence, through adequately powered RCTs with longitudinal and cross-context follow-up; (2) Holistic accessibility and inclusive design, embedding configurability, assistive features, and cultural adaptability as core system components; (3) Participatory co-design and implementation research, evaluating how caregiver involvement in design and training influences sustainability and real-world impact.

By addressing these priorities, future work can move beyond proof-of-concept studies toward scalable, inclusive, and evidence-based GARIs that meaningfully support children with ASD across diverse learning and living environments.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

Appendix I

Author	Title	Publisher	Pub Type
Lyu et al. (2024) [33]	EMooly: Supporting Autistic Children in Collaborative Social-Emotional Learning with Caregiver Participation through Interactive AI-infused and AR Activities	ACM	Conference
Lyu et al. (2023) [38]	Eggly: Designing Mobile Augmented Reality Neurofeedback Training Games for Children with Autism Spectrum Disorder	ACM	Conference
Liu et al. (2024) [30]	Foldiverse: Augmenting Paper Folding Physiotherapy for Children with Autism via Family-Centered Mixed Reality Design	Taiwanese Journal	Journal
Liu et al. (2017) [26]	Feasibility of an autism-focused augmented reality smartglasses system for social communication and behavioral coaching	Healthcare Journal	Journal
Amara et al. (2023) [25]	AR Computer-Assisted Learning for Children with ASD based on Hand Gesture and Voice Interaction	Egyptian Journal	Journal

Cai et al. (2023) [22]	Starrypia: An AR Gamified Music Adjuvant Treatment Application for Children with Autism Based on Combined Therapy	Elsevier	Journal
Hsu & Lee (2020) [23]	Using augmented reality technology with serial learning framework to develop a serial social story situation board game system for children with autism to improve social situation understanding and social reciprocity skills	LNCS (Springer)	Conference
Huang & Lee (2020) [45]	Using augmented reality and concept mapping to improve ability to master social relationships and social reciprocity for children with autism spectrum disorder	LNCS (Springer)	Conference
Hu et al. (2025) [42]	The Impact of AR Embodied Gaming and 2D Gaming on Children's Social Cognition and Learning Experience: An fNIRS Controlled Trial	IJHCI (Elsevier)	Journal
Lee & Hsu (2024) [46]	Applied the augmented reality technology combined with social stories strategies and computational thinking games to improve the social skills of children with ASD	LNCS (Springer)	Conference
Lee & Huang (2024) [39]	Improving social skills in children with autism spectrum disorder using augmented reality and mixed reality technology combined with concept maps	LNCS (Springer)	Conference
Lee & Wang (2025) [36]	Applying theatre-based role-playing combined with AR and VR game strategies to enhance imagination and symbolic play skills in children with autism spectrum disorder	LNCS (Springer)	Conference
Lee & Chen (2025) [47]	Using asymmetric AR and VR technologies combined with peer collaboration and symbolic play to enhance intent understanding and empathy in children with autism	LNCS (Springer)	Conference
Lee (2021) [34]	Kinect-for-windows with augmented reality in an interactive roleplay system for children with an autism spectrum disorder	LNCS (Springer)	Conference
Nazari et al. (2023) [28]	Interactive AR Applications for Nonspeaking Autistic People? - A Usability Study	CHI (ACM)	Conference
Wongwan et al. (2025) [27]	Designing a Gamified Mixed Reality System for Social Skills Development in High-Functioning Children with Autism Spectrum Disorder	IEEE DAMT/NC ON	Conference
Samantaray et al. (2023)	Development of an Augmented Reality based Joint Attention Training Platform for Autistic Children	IEEE ICCCNT	Conference
Wang & Lee (2020) [32]	Social Intervention Strategy of Augmented Reality Combined with Theater-Based Games to Improve the Performance of Autistic Children in Symbolic Play and Social Skills	LNCS (Springer)	Conference
Avila-Pesantez et al. (2018) [37]	Towards the improvement of ADHD children through augmented reality serious games: Preliminary results	IEEE EDUCON	Conference
Mendoza-Marin et al. (2022) [24]	Technological Solution For Children With ADHD By Using Augmented Reality In Serious Games	IEEE ICALTER	Conference
Li et al. (2023) [31]	FaceMe: An agent-based social game using augmented reality for the emotional development of children with autism spectrum disorder	IJHCS (Elsevier)	Journal
Antao et al. (2020) [35]	Use of Augmented Reality with a Motion-Controlled Game Utilizing Alphabet Letters and Numbers to Improve Performance and Reaction Time Skills for People with Autism Spectrum Disorder	Cyberpsychology (Liebert)	Journal

Nekar, Kang et al. (2022) [41]	Feasibility of Using Multiplayer Game-Based Dual-Task Training with Augmented Reality and Personal Health Record on Social Skills and Cognitive Function in Children with Autism	Children (MDPI)	Journal
Nekar, Lee et al. (2022) [40]	Effects of Augmented Reality Game-Based Cognitive-Motor Training on Restricted and Repetitive Behaviors and Executive Function in Patients with Autism Spectrum Disorder	Healthcare (MDPI)	Journal

References

1. World Health Organisation. *Autism*. 2023 2023; Available from: <https://www.who.int/news-room/fact-sheets/detail/autism-spectrum-disorders>.
2. Lingala, J., et al., *Executive Functions in Children with Autism: An Overview*. 2021.
3. Simonoff, E., et al., *Psychiatric Disorders in Children With Autism Spectrum Disorders: Prevalence, Comorbidity, and Associated Factors in a Population-Derived Sample*. *Journal of the American Academy of Child & Adolescent Psychiatry*, 2008. **47**(8): p. 921-929.
4. National Autism, A., *Autism Fact Sheet - National Autism Association*. 2012.
5. Hyman, S.L., et al., *Identification, Evaluation, and Management of Children With Autism Spectrum Disorder*. *Pediatrics*, 2020. **145**(1): p. e20193447.
6. Cavus, N., et al., *A Systematic Literature Review on the Application of Machine-Learning Models in Behavioral Assessment of Autism Spectrum Disorder*. *Journal of Personalized Medicine*, 2021. **11**(4): p. 299.
7. El Shemy, I., et al., *Augmented reality-enhanced language learning for children with autism spectrum disorder: a systematic literature review*. *Behaviour & Information Technology*, 2024. **43**(16): p. 4097-4124.
8. Ribeiro Silva, L., et al., *Effects of a collaborative gamification on learning and engagement of children with Autism*. *Universal Access in the Information Society*, 2025. **24**(1): p. 911-932.
9. Navan, A.A., et al., *Using Gamification to Improve the Education Quality of Children with Autism*. *Revista científica*, 2020(37): p. 90-106.
10. Berenguer, C., et al., *Exploring the impact of augmented reality in children and adolescents with autism spectrum disorder: A systematic review*. *International Journal of Environmental Research and Public Health*, 2020. **17**(17): p. 6143.
11. Khowaja, K., et al., *Augmented reality for learning of children and adolescents with autism spectrum disorder (ASD): A systematic review*. *IEEE Access*, 2020. **8**: p. 78779-78807.
12. Camargo, M.C., et al. *Designing gamified interventions for autism spectrum disorder: a systematic review*. in *Joint international conference on entertainment computing and serious games*. 2019. Springer.
13. Khowaja, K. and B. Banire. *Use of augmented reality for social communication skills in children and adolescents with autism spectrum disorder (ASD): A systematic review*. in *2019 IEEE 6th international conference on engineering technologies and applied sciences (ICETAS)*. 2019.
14. Wang, T., et al., *The use of gamified interventions to enhance social interaction and communication among people with autism spectrum disorder: A systematic review and meta-analysis*. *International Journal of Nursing Studies*, 2025. **165**: p. 105037.

15. Page, M.J., et al., *The PRISMA 2020 statement: an updated guideline for reporting systematic reviews*. BMJ, 2021. **372**: p. n71.
16. Eckert, M., J.S. Volmerg, and C.M. Friedrich, *Augmented Reality in Medicine: Systematic and Bibliographic Review*. JMIR mHealth and uHealth, 2019. **7(4)**: p. e10967.
17. Merino, L., et al. *Evaluating Mixed and Augmented Reality: A Systematic Literature Review (2009-2019)*. 2020.
18. Krokchina, J.A., et al., *An examination of mobile learning adoption in higher education: Research trends in twenty years*. Contemporary Educational Technology, 2024. **16(4)**: p. ep542.
19. Hong, Q.N., et al., *Mixed methods appraisal tool (MMAT), version 2018*. Registration of copyright, 2018. **1148552(10)**: p. 1-7.
20. Csikszentmihalyi, M., *Flow: The psychology of optimal experience*. Vol. 1990. 1990: Harper & Row New York.
21. Adams, N., T.D. Little, and R.M. Ryan, *Self-Determination Theory*, in *Development of Self-Determination Through the Life-Course*, M.L. Wehmeyer, et al., Editors. 2017, Springer Netherlands: Dordrecht. p. 47-54.
22. Cai, Y., et al. *Starrypia: An AR Gamified Music Adjuvant Treatment Application for Children with Autism Based on Combined Therapy*. 2023. New York, NY, USA: Association for Computing Machinery.
23. Hsu, H.-T. and I.J. Lee. *Using Augmented Reality Technology with Serial Learning Framework to Develop a Serial Social Story Situation Board Game System for Children with Autism to Improve Social Situation Understanding and Social Reciprocity Skills*. 2020. Cham: Springer International Publishing.
24. Mendoza-Marin, A.A., M.A. Dueñas-Guevara, and D. Burga. *Technological Solution For Children With ADHD By Using Augmented Reality In Serious Games*. 2022.
25. Amara, K., et al., *AR Computer-Assisted Learning for Children with ASD based on Hand Gesture and Voice Interaction*. IETE Journal of Research, 2023. **69(12)**: p. 8659-8675.
26. Liu, R., et al., *Feasibility of an Autism-Focused Augmented Reality Smartglasses System for Social Communication and Behavioral Coaching*. Frontiers in Pediatrics, 2017. **5**.
27. Wongwan, N., et al. *Designing a Gamified Mixed Reality System for Social Skills Development in High-Functioning Children with Autism Spectrum Disorder*. 2025.
28. Nazari, A., et al. *Interactive AR Applications for Nonspeaking Autistic People? - A Usability Study*. 2023. New York, NY, USA: Association for Computing Machinery.
29. Samantaray, A., et al. *Development of an Augmented Reality based Joint Attention Training Platform for Autistic Children*. 2023.
30. Liu, J.J., et al. *Foldiverse: Augmenting Paper Folding Physiotherapy for Children with Autism via Family-Centered Mixed Reality Design*. 2024. New York, NY, USA: Association for Computing Machinery.
31. Li, J., et al., *FaceMe: An agent-based social game using augmented reality for the emotional development of children with autism spectrum disorder*. International Journal of Human-Computer Studies, 2023. **175**: p. 103032.
32. Wang, W.-Z. and I.J. Lee. *Social Intervention Strategy of Augmented Reality Combined with Theater-Based Games to Improve the Performance of Autistic Children in Symbolic Play and Social Skills*. 2020. Cham: Springer International Publishing.

33. Lyu, Y., et al., *EMooly: Supporting Autistic Children in Collaborative Social-Emotional Learning with Caregiver Participation through Interactive AI-infused and AR Activities*. Proc. ACM Interact. Mob. Wearable Ubiquitous Technol., 2024. **8**(4): p. 203:1-203:36.
34. Lee, I.J., *Kinect-for-windows with augmented reality in an interactive roleplay s ystem for children with an autism spectrum disorder*. Interactive Learning Environments, 2021. **29**(4): p. 688-704.
35. Antão, J.Y.F.d.L., et al., *Use of Augmented Reality with a Motion-Controlled Game Utilizing Alphabet Letters and Numbers to Improve Performance and Reaction Time Skills for People with Autism Spectrum Disorder*. Cyberpsychology, Behavior, and Social Networking, 2020. **23**(1): p. 16-22.
36. Lee, I.J. and W.-Z. Wang, *Applying theatre-based role-playing combined with AR and VR game strat egies to enhance imagination and symbolic play skills in children with autism spectrum disorder*. Universal Access in the Information Society, 2025.
37. Avila-Pesantez, D., et al. *Towards the improvement of ADHD children through augmented reality serious games: Preliminary results*. 2018.
38. Lyu, Y., et al., *Eggly: Designing Mobile Augmented Reality Neurofeedback Training Games for Children with Autism Spectrum Disorder*. Proc. ACM Interact. Mob. Wearable Ubiquitous Technol., 2023. **7**(2): p. 67:1-67:29.
39. Lee, I.J. and Y.-C. Huang, *Improving social skills in children with autism spectrum disorder using augmented reality and mixed reality technology combined with concept maps*. Universal Access in the Information Society, 2024. **24**(2): p. 1255-1281.
40. Nekar, D.M., et al., *Effects of Augmented Reality Game-Based Cognitive–Motor Training on Restricted and Repetitive Behaviors and Executive Function in Patients w ith Autism Spectrum Disorder*. Healthcare, 2022. **10**(10): p. 1981.
41. Nekar, D.M., et al., *Feasibility of Using Multiplayer Game-Based Dual-Task Training with Augmented Reality and Personal Health Record on Social Skills and Cognitive Function in Children with Autism*. Children, 2022. **9**(9): p. 1398.
42. Hu, D., et al., *The Impact of AR Embodied Gaming and 2D Gaming on Children’s Social Co gnition and Learning Experience: An fNIRS Controlled Trial*. International Journal of Human–Computer Interaction, 2025. **41**(23): p. 15007–15024.
43. Whyte, E.M., J.M. Smyth, and K.S. Scherf, *Designing serious game interventions for individuals with autism*. Journal of autism and developmental disorders, 2015. **45**(12): p. 3820-3831.
44. Feng, J., et al., *Key factors influencing educational technology adoption in higher education: A systematic review*. PLOS Digital Health, 2025. **4**(4): p. e0000764.
45. Huang, Y.-C. and I.J. Lee. *Using Augmented Reality and Concept Mapping to Improve Ability to Mast er Social Relationships and Social Reciprocity for Children with Autis m Spectrum Disorder*. 2020. Cham: Springer International Publishing.
46. Lee, I.J. and H.-T. Hsu, *Applied the augmented reality technology combined with social stories strategies and computational thinking games to improve the social skills of children with ASD*. Interactive Learning Environments, 2024. **32**(10): p. 6346-6374.
47. Lee, I.J. and C.-M. Chen, *Using asymmetric AR and VR technologies combined with peer collaboration and symbolic play to enhance intent understanding and empathy in children with autism*. Interactive Learning Environments, 2025. **0**(0): p. 1-38.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

