

A systematic Literature Review on Mobile Application Development for Children with Autism Spectrum Disorder (ASD)

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ABSTRACT

Mobile applications are increasingly used to support children with autism spectrum disorder (ASD). This systematic literature review analyzed studies published between 2018 and 2025 on mobile app development for children with ASD. Using PRISMA guidelines, 78 records were identified from Scopus and IEEE Xplore databases, and 15 met the inclusion criteria. Study quality was evaluated using the CASP checklist, with 47% (7/15) achieving high quality scores. The findings showed geographic diversity, with many studies conducted in Asia, and varied methodological quality. Several design approaches were used, including User-Centered Design, Applied Behavior Analysis, TEACCH, gamification, and artificial intelligence. Intervention-based studies reported positive outcomes in communication, emotional regulation, daily living skills, and user engagement. However, many studies relied on small sample sizes and short testing periods, limiting generalizability. Applications combining multiple therapeutic and design approaches demonstrated higher usability and effectiveness than single-method systems, with usability scores reaching up to 97/100. This review provides evidence-based guidance for researchers, developers, and clinicians working to advance mobile interventions for children with ASD.

KEYWORDS: Autism Spectrum Disorder (ASD), Mobile Applications Development, Early Intervention, Assistive Technology, User-Centered Design (UCD).

1. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by persistent deficits in social communication and social interaction, alongside restricted and repetitive patterns of behavior, interests, or activities (American Psychiatric Association, 2013). Recent epidemiological estimates indicate that approximately 1 in 36 children are diagnosed with ASD (Maenner et al., 2023), while national data from Thailand suggest a prevalence of around 15 per 1,000 children under the age of 15 (Deeon, 2025). Because ASD is a spectrum disorder, children can have very different symptoms and needs. Some children need only a little support, while others need much more help. The DSM-5 delineates three severity levels: Level 1 (requiring support), characterized by difficulties initiating social interactions and inflexibility in behavior; Level 2 (requiring substantial support), marked by notable deficits in verbal and nonverbal communication; and Level 3 (requiring very substantial support), defined by severe impairments in communication and highly restricted, repetitive behaviors (American Psychiatric Association, 2013). Early intervention is widely recognized as a critical determinant of long-term outcomes, with evidence indicating that intervention during early developmental periods particularly between ages 2 and 6 can significantly enhance language development, social interaction, and daily living skills.

In recent years, mobile technologies have emerged as promising tools for supporting children with ASD. Smartphones and tablets provide accessible, portable, and relatively low-cost platforms capable of integrating visual, auditory, and interactive elements that align with the learning preferences of many autistic children. Unlike traditional clinic-based therapies that depend heavily on specialist

availability, mobile applications can be implemented across home, school, and community environments, thereby increasing flexibility and continuity of intervention. Mobile applications provide several advantages over traditional approaches, including accessibility, engagement, and consistency (Liu et al., 2023). They also support objective data collection, can reduce costs by limiting intensive one-on-one clinical time (Mahmoudi et al., 2024), and allow personalized experiences through adaptive features tailored to each child's needs.

Several therapy methods have been integrated into mobile apps:

- Applied Behavior Analysis (ABA) a well-established behavioral intervention that employs systematic reinforcement and task decomposition to develop communication, social, and adaptive skills (Xu et al., 2025; Mruzek et al., 2019).
- Augmentative and Alternative Communication (AAC) is a set of strategies and tools designed to supplement or replace natural speech for individuals with complex communication needs (Castellanos et al., 2022; Laubscher et al., 2019).
- Picture Exchange Communication System (PECS) is a structured communication system that utilizes picture symbols to enable non-verbal or minimally verbal children to express needs and intentions (Castellanos et al., 2022).
- Treatment and Education of Autistic and related Communication Handicapped Children (TEACCH) Apps show visual schedules and step-by-step instructions (Rojas & Chavarriaga, 2023; Shminan et al., 2020).

Table 1 Search string development (IEEE Xplore).

Step	Search terms	Results
1	"Autism mobile application development"	122
2	("Autism mobile application development") AND ("child")	100
3	("Autism mobile application development") AND ("child") AND ("communication")	73
4	("Autism mobile application development") AND ("child") AND ("communication") AND ("behavior")	40

- Video Modeling Demonstrating target behaviors through video examples (Laubscher et al., 2019; Kalantarian et al., 2019).

Many apps also use game features like points and rewards to keep children interested. Some use newer technology like machine learning to adjust to each child or augmented reality for practicing social skills in a safe environment.

However, despite the thousands of autism-related applications available in app stores, relatively few have undergone rigorous scientific evaluation (Liu et al., 2023). This creates a significant challenge for parents, educators, and clinicians seeking evidence-based tools to support children with ASD. This review examines mobile apps for children with ASD, focusing on design, target skills, implementation, and effectiveness. The review answers four questions:

- RQ1: What are the main trends in mobile app development for autism?
- RQ2: What design methods are most commonly used?
- RQ3: How are apps tested in real situations?
- RQ4: What results are reported from using these apps?

By addressing these research questions, this review offers guidance for advancing evidence-based mobile interventions for autism.

2. MATERIALS AND METHODS

2.1 Research Design

This study is a Systematic Literature Review (SLR) using a clear, step-by-step method to review research on mobile apps for children with ASD, ensuring the process is systematic and repeatable. PRISMA guidelines were followed through four stages: Identification, Screening, Eligibility, and Inclusion. Only peer-reviewed publications from 2018–2025 were included, comprising journal articles and full conference papers (≥ 4 pages) from established technical venues such as IEEE and ACM, due to the increased focus on autism mobile technologies, especially with the rise of AI and machine learning.

2.2 Search Strategy

2.2.1 Database Selection and Rationale

This SLR used two complementary databases: Scopus and IEEE Xplore. Scopus was selected for its broad multidisciplinary coverage, as it indexes substantially more peer-reviewed journals than Web of Science, with notable strengths in engineering, computer science, and applied domains (Falagas et al., 2008; Mongeon & Paul-Hus, 2016). IEEE Xplore was included to capture high-impact technical publications in computer science, artificial intelligence, and biomedical engineering, providing access to IEEE journals, conference proceedings, and technical literature (Franco et al., 2021). The Scopus search yielded 38 records, while IEEE Xplore returned 40 records, resulting in a combined total of 78 records prior to screening. Of the 40 IEEE records, full-text access was available for four studies. After screening and removing one duplicate, three IEEE studies met the inclusion criteria and were incorporated into the final analysis.

2.2.2 Boolean Search String Development

Table 1 shows the evolution of the search string:

Table 2 Search string development (Scopus).

Step	Search terms	Results
1	"Autism mobile application development"	277
2	("Autism mobile application development") AND ("child")	219
3	("Autism mobile application development") AND ("child") AND ("communication")	96
4	("Autism mobile application development") AND ("child") AND ("communication") AND ("behavior")	38

The Boolean search string was adapted to the syntax of each database. In Scopus, field-specific tags were applied using the Advanced Search interface: (TITLE-ABS-KEY ("Autism mobile application development") AND TITLE-ABS-KEY("child") AND TITLE-ABS-KEY("communication") AND TITLE-ABS-KEY("behavior")). In IEEE Xplore, the Advanced Search interface was used with the "All Metadata" field, applying equivalent keywords: ("Autism mobile application development") AND ("child") AND ("communication") AND ("behavior"). Both searches were executed on 27 January 2026. Total Records Identified: 78

2.3 Inclusion and Exclusion Criteria

We included peer-reviewed articles and conference papers 2018-2025 about mobile apps for children aged 0-18 with autism that help with communication, behavior, emotions, or daily skills, written in English. Studies were excluded if they focused on adults (19+ years), used non-mobile technologies (e.g., desktop-only applications), addressed only diagnosis or academic skills without intervention components, or were limited to parent education without direct child engagement. Short conference abstracts (<2 pages) and non-peer-reviewed gray literature were excluded to ensure methodological rigor. However, full conference papers (≥4 pages) from established technical

venues (e.g., IEEE, ACM conferences) were included if they:

- Underwent peer review
- Provided sufficient methodological detail
- Reported empirical data or design validation
- Addressed the research questions directly

This inclusive approach was adopted because:

- Mobile application development research is frequently published in high-quality technical conferences (IEEE, ACM)
- Conference papers in computer science often contain rigorous technical contributions equivalent to journal articles
- Excluding all conference papers would omit significant technical innovations in this rapidly evolving field
- Precedent exists in systematic reviews of technology-mediated interventions

One study (Zamry et al., 2022), although classified as a literature review, was retained as a justified exception because it presented an original methodological contribution: a religiously-aligned Islamic guideline framework for autism mobile application development derived from systematic literature synthesis. This exception was explicitly noted and consistently applied throughout the review process. Unlike Liu et al. (2023) and Concepción Patiño et al. (2022), which provided descriptive surveys of existing applications or AR interventions without novel frameworks, Zamry et al. developed and validated a structured guideline that directly informs mobile application design processes. This methodological innovation analogous to design science research outputs warranted inclusion as it addresses RQ2 (design methodologies) by proposing evidence-based

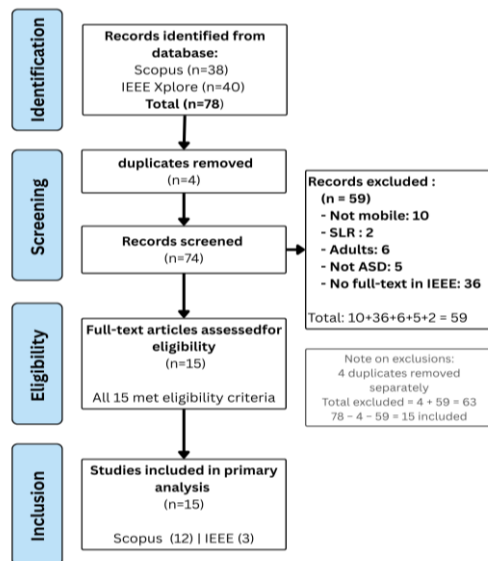


Figure 1 presents the PRISMA flow diagram summarizing the study selection process.

design principles absent from conventional development approaches.

2.4 Quality Assessment

The Critical Appraisal Skills Programme (CASP) checklist was used to assess the methodological quality of included studies (Critical Appraisal Skills Programme, 2018). CASP is a widely recognized tool for evaluating research studies in systematic reviews, as it allows for systematic assessment of trustworthiness and quality across various study designs. Each study was evaluated across eight CASP criteria: (1) clarity of research aims, (2) appropriateness of methodology, (3) research design, (4) recruitment strategy, (5) data collection methods, (6) consideration of researcher-participant relationship, (7) ethical considerations, and (8) rigor of data analysis. Each criterion was scored as 1 (Yes) if adequately addressed or 0 (No/Unclear) if not sufficiently reported. Total quality scores ranged from 0 to 8. Studies scoring 7–8 were classified as high quality, 6 as medium-high, 5 as medium, and 1–4 as low quality. Quality assessment was conducted by the primary reviewer (H.S.), with a second reviewer independently verifying assessments for 30% of studies to ensure

consistency; discrepancies were resolved through discussion. The CASP Qualitative Checklist was selected for its structured approach to evaluating methodological transparency across diverse study designs. Although originally developed for qualitative health research, its criteria are broadly applicable to the heterogeneous designs included in this review, consistent with its use in mixed-methods systematic reviews of technology-mediated interventions.

2.5 PRISMA Flow Diagram

The PRISMA diagram illustrates the overall study selection process. Searches conducted in Scopus and IEEE Xplore identified a combined total of 78 records (38 from Scopus and 40 from IEEE Xplore). Figure 1 illustrates the study selection process. A total of 78 records were identified through database searching (38 from Scopus and 40 from IEEE Xplore). Four duplicate records were removed, including three repeated entries within Scopus and one overlapping record between Scopus and IEEE Xplore, leaving 74 records for screening. After title and abstract screening, 59 records were excluded for the following reasons: 10 did not involve mobile applications, 36 records were excluded due to the unavailability of accessible full-text versions during the screening process, 6 focused exclusively on adult populations, 5 were not related to autism, and 2 were systematic literature reviews. Fifteen full-text articles were assessed for eligibility, all of which met the inclusion criteria and were included in the primary analysis (12 from Scopus and 3 from IEEE Xplore). Screening and eligibility assessment were conducted independently by two reviewers, with high inter-rater agreement. One study (Zamry et al., 2022) was retained despite being classified as a literature review, as it met the predefined inclusion criteria described in Section 2.3.

Table 3 Overview of selected studies.

No.	Journal / Year	Country	Study Type	Primary Focus	RQ Addressed
1	Zamry et al. (2022) Religious Guideline	Malaysia	SLR + Guideline Development	Religious boundaries for autism apps (Islamic guidelines)	RQ2
2	Rojas & Chavarriaga (2023) TEAutonomía	Chile/Spain	Design, Development & Usability Evaluation	Dynamic activity design for autonomy (TEAutonomia app)	RQ1, RQ2, RQ3, RQ4
3	Yap et al. (2019) App4Autism	Malaysia	Design, Development & Pilot Study	Emotion recognition with heart rate monitoring (App4Autism)	RQ2, RQ3, RQ4
4	Shminan et al. (2020) AutiTEACCH	Malaysia	Design, Development & Multi-Stage Evaluation	Caregiver training for TEACCH implementation (AutiTEACCH)	RQ2, RQ3, RQ4
5	Bir et al. (2023) ML Emotion	India	ML System Design + Algorithm Development	Machine learning for emotion recognition	RQ2
6	Xu et al. (2025) Adaptive Games	China	Framework Development + Prototype	Adaptive multimodal serious games with DDA algorithm	RQ1, RQ2, RQ3
7	Castellanos et al. (2022) Deep Mobile	Taiwan/China	System Design + Architecture Documentation	Deep mobile linguistic therapy (NLP + Speech)	RQ2
8	Purnama et al. (2021) Squizzy	Indonesia	Design, Development & Evaluation	Educational software for cognitive skills (Squizzy)	RQ2, RQ3, RQ4
9	Laubscher et al. (2019) Video VSDs	USA	Single-Case Experimental Design (Pilot)	Video visual scene displays for play communication	RQ2, RQ3, RQ4
10	Kalantarian et al. (2019) Guess What?	USA	System Design + Algorithm Validation	Crowdsourcing emotion data via charades game (Guess What?)	RQ2, RQ3
11	Mruzek et al. (2019) - iOS Toilet Training	USA (Multi- site)	Pilot Randomized Controlled Trial	iOS-based toilet training app with moisture sensor	RQ2, RQ3, RQ4
12	Hussain et al. (2023) IoT System	India	System Design	IoT-based monitoring system (EEG + sensors)	RQ2
13	Arbaoui et al. (2024) - PECS App	Morocco	Design & Development	Context-aware PECS mobile app for communication	RQ2, RQ3
14	Chistol et al. (2023) - Autism Assistant	Romania	Single-Case Experimental Study	Personalized attention strategies in tablet-based learning app	RQ1, RQ2, RQ3, RQ4
15	Chinchay et al. (2024) - Attention	Colombia/ Spain	Single-Case Experimental Study	Personalized attention strategies in tablet-based learning app	RQ2, RQ3, RQ4

3. RESULTS AND DISCUSSION

3.1 Overview of Selected

Table 3 summarizes the characteristics of the 15 primary studies included in this review, while Table 4 provides detailed methodological and technical information for each study. The 15 studies came from diverse geographic regions: 8 from Asia (53%) including Malaysia, India, China, Indonesia, and Taiwan; 5 from the Americas (33%) including the United States, Chile, and

Colombia; 1 from Europe (7%) from Romania; and 1 from North Africa (7%) from Morocco. Several studies involved cross-national collaboration (e.g., Chile/Spain and Colombia/Spain). This geographic diversity, extending beyond previous reviews to include Latin America, Eastern Europe, and North Africa, reflects the growing global interest in mobile ASD interventions. The studies were published between 2019 and 2025.

Table 4 Summary of Study Characteristics.

No.	Sample Size	Age Range	Duration	Platform	Framework/Approach	Primary Outcome
1	SLR: 35 autism + 26 religious app papers	N/A	N/A	Mobile apps	Islamic guidelines for autism apps	24 design guidelines (11 multimedia 13 features)
2	12 children with ASD	3-8 years	4 weeks	Android tablet	TEACCH, UCD	SUS 97.08/100 (Grade A+), high usability, parent satisfaction
3	10 children with ASD	7-12 years	3 sessions	Android (smartphone + smartwatch)	Gamification, emotion recognition	Improved emotion recognition, acceptable heart rate monitoring
4	Stage 1: 2 experts Stage 2: 5 caregivers Stage 3: 24 caregivers	N/A (Caregivers)	3-stage evaluation	Android	TEACCH, ADDIE, FRAME, Behaviorism	SUS 77.5/100 (Grade B), IMMS satisfaction 3.98/5
5	Not specified	6-14 years	N/A	Mobile app	Machine learning (SVM, RF, NN)	Proposed ML framework (not tested with users)
6	30 children with ASD	3-6 years	8 weeks	Android tablet	ABA, Gamification, DDA algorithm	Improved social skills, communication attention span
7	No users	Children (age not specified)	N/A	Android + iOS	NLP, PECS, AAC, Speech Recognition	System architecture validated (no us testing)
8	10 children + 5 therapists + 5 parents	5-15 years	Short-term	Android tablet	Cognitive therapy	Positive feedback, reduces therapist workload, portable
9	1 dyad (1 ASD + 1 peer)	8 years	2 months (30 sessions)	iPad (GoVisual app)	AAC, Video VSDs, Peer-mediated	Large effect (Tau-U=0.8), +5.8 to +11 turns per session
10	8 children with ASD + 2 raters	Mean 8.5±1.85 years	90-second sessions	Smartphone (charades game)	Video modeling, AI classifiers	High emotion labeling: Disgust 94%, Surprised 92%, Neutral 81%
11	32 children (16 WMP, 16 SBT)	3-6 years	12 weeks + 3-month follow-up	iOS (iPod + moisture sensor)	ABA, Rapid Toilet Training	84% retention, WMP achieved similar outcomes with less daily time (p=0.02)
12	No users	Children (age not specified)	N/A	IoT-based monitoring system (EEG + sensors)	EEG, heart rate monitoring	NOT implemented, NOT tested
13	Not specified (design study)	Children (age not specified)	N/A	Mobile app (Android)	PECS, Context-awareness, UCD	Personalized PECS with contextual picture adaptation based on location and activity
14	60 stakeholders (parents, teachers, therapists) + children with ASD	Children (age not specified)	Cross-sectional	Mobile (Android) + Web	ABA, HCD (Double Diamond), UCD	High user satisfaction; supports parer as co-therapist in home-based ABA therapy
15	5 children with ASD	5-18 years	Multiple sessions (baseline + intervention + post-intervention)	Android tablet (Samsung Galaxy Tab S4, web-based)	Personalized attention strategies, UCD, Multiple-baseline desi	Improved attention and autonomy; auditory + visual stimuli effective for ASD engagement

Table 5 CASP Quality Assessment

NO.	Aims	Method	Design	Recruit	Data	Relationship	Ethics	Analysis	Total
1	1	1	1	1	1	1	1	1	8/8
2	1	1	1	1	1	1	0	1	7/8
3	1	1	1	1	1	1	0	1	7/8
4	1	1	1	0	1	1	0	1	6/8
5	1	1	1	1	1	1	0	1	7/8
6	1	1	1	0	0	1	0	0	4/8
7	1	1	1	0	1	1	0	1	6/8
8	1	0	1	0	0	1	0	0	3/8
9	1	1	1	0	1	0	0	0	4/8
10	1	1	1	0	1	0	0	1	5/8
11	1	1	1	1	1	1	1	1	8/8
12	1	1	0	0	0	1	1	0	4/8
13	1	1	1	0	1	0	0	1	5/8
14	1	1	1	1	1	1	0	1	7/8
15	1	1	1	1	1	1	1	0	7/8

Table 4 summarizes key characteristics of the 15 studies, including sample sizes, age ranges, intervention durations, platforms, frameworks, and primary outcomes.

Study types included seven design and evaluation studies involving users (47%), one randomized controlled trial (7%), three single-case experimental studies (20%), one systematic literature review (7%), and three design-only proposals without user testing (20%). Sample sizes varied considerably across the empirical studies, ranging from small groups of children to mixed samples involving caregivers, therapists, and experts. One study involved 32 children, whereas several design-oriented and system-architecture studies did not include participants. Testing durations ranged from brief single-session evaluations to multi-week interventions lasting up to eight or twelve weeks. Most empirical studies reported relatively short evaluation periods, typically under eight weeks, while a few studies did not specify the duration.

3.2 Study Quality

Table 5 presents the CASP quality assessment for all 15 studies. Seven studies achieved high quality (7–8 points), two medium-high (6 points), two medium (5

points), and four low qualities (1–4 points), with an average of approximately 6 out of 8

Most studies clearly stated their aims and employed appropriate methodological approaches, as reflected in the overall CASP scores. However, the quality assessment revealed notable patterns of methodological weakness. The most frequently absent criterion was ethical reporting, which was inadequately addressed in 11 of 15 studies (73%), raising concerns about participant protection standards in technology-mediated pediatric research. Recruitment transparency was also problematic, with 8 studies (53%) failing to clearly describe their selection procedures, limiting replicability. Notably, the two highest-quality studies (Zamry et al. and Mruzek et al.) were those that combined rigorous theoretical frameworks with systematic evaluation procedures, suggesting that methodological quality is associated with the integration of established intervention protocols rather than technological complexity alone.

3.3 Research Trends (RQ1)

Several important trends emerged in mobile application development for autism.

- The first trend is the shift from communication-focused tools to

applications targeting multiple developmental skills, including emotional regulation, daily activities, social interaction, attention, and independence. Chinchay et al. specifically targeted attention assessment through personalized digital strategies, while Chistol et al. developed a home-based ABA platform enabling parents to support therapy outside clinical settings. For example, the TEAutonomía application developed by Rojas and Chavarriaga supports daily routines and autonomy in addition to communication.

- The second trend is the adoption of context-aware and adaptive frameworks. Arbaoui et al. introduced a context-aware PECS application that adapts picture cards dynamically based on the user's location and activity, representing a significant advancement in PECS-based communication tools.
- The third trend is the increased use of multimodal feedback. Most applications integrate visual, auditory, and occasionally tactile elements to enhance engagement and support learning. Prior research indicates that effective autism applications typically rely on multiple feedback modalities. For example, Xu et al. incorporated visual, auditory, and tactile responses within their adaptive game-based intervention, demonstrating how multimodal feedback can improve user interaction and task performance.
- The fourth trend is the growing integration of artificial intelligence. AI and adaptive techniques were incorporated in approximately nine studies (60%),

including adaptive difficulty systems, context-aware personalization, and emotion recognition. Machine learning for emotion detection was implemented in three studies (20%), while one study applied natural language processing for speech-based interaction.

- The fifth trend relates to cultural considerations. Only one study explicitly addressed cultural and religious factors, developing design guidelines aligned with Islamic values, highlighting the limited attention given to sociocultural adaptation in current applications.
- The sixth trend is increased parent involvement. Several intervention-based applications incorporated caregiver participation through training, monitoring tools, and communication features. For instance, AutiTEACCH was designed to support caregiver training, while another intervention integrated parent-clinician communication to facilitate remote support.

3.4 Design Methodologies (RQ2)

Table 6 summarizes the technological features and development approaches adopted across the included studies. The findings highlight the multidisciplinary nature of mobile application development for children with autism spectrum disorder, combining therapeutic frameworks, software engineering practices, and interactive technologies. User-Centered Design emerged as one of the most commonly applied approaches, particularly in studies involving usability testing and iterative development. Behavioral and structured learning frameworks were also widely integrated, including Applied Behavior Analysis and TEACCH, especially in intervention-based applications.

Gamification elements such as rewards, challenges, and interactive activities were frequently used to increase engagement and motivation. Artificial intelligence and adaptive techniques were incorporated in several studies (60%), primarily for emotion recognition, adaptive difficulty adjustment, and speech-based interaction. Machine learning was used for facial emotion detection, while natural language processing supported speech and language-based interventions. These implementations ranged from conceptual system designs to validated applications. In terms of interaction design, touchscreens represented the dominant input modality across most applications, reflecting their accessibility for children with ASD. Additional interaction methods included camera-based facial recognition (27%), voice and microphone input, and physiological sensors such as heart rate or moisture detection (13%). These multimodal interfaces supported personalized and adaptive learning experiences. Most applications were developed for mobile platforms, with Android being the most common operating system, followed by iOS and cross-platform solutions. Tablets were frequently used in intervention contexts due to their suitability for structured learning and visual interaction. Regarding connectivity, many applications were designed to function offline (40%), supporting accessibility in home and therapy settings. A smaller number relied on cloud-based services, Bluetooth connectivity, or hybrid architectures for data synchronization, remote monitoring, and clinician communication. Overall, the results indicate a shift toward integrated, adaptive, and user-focused technological solutions, where therapeutic frameworks are combined with interactive design and emerging artificial intelligence

capabilities to support learning, communication, and daily functioning in children with ASD.

3.5 Implementation and Testing (RQ3)

Ten studies (67%) evaluated their applications with end users, including children, parents, therapists, and occasionally teachers or peer participants. Testing was conducted across multiple contexts, including home, school, clinical, and laboratory environments, with several studies combining more than one setting. Participant involvement varied, with parents participating in many intervention-based applications, followed by therapists, teachers, and peer-supported interventions. Sample sizes were generally small, with most studies involving fewer than 30 children and only one study including a larger cohort of 32 participants. Testing durations ranged from single-session evaluations to extended interventions lasting up to 12 weeks, with most studies conducted over short-term periods. This represents a critical methodological limitation: short evaluation windows are insufficient to assess skill generalization, maintenance of gains, or potential adverse effects of prolonged app use. Furthermore, the predominance of small samples and single-site designs limits the external validity of reported outcomes. Notably, only Mruzek et al. included a follow-up assessment beyond the intervention phase, highlighting the urgent need for longitudinal evaluation designs in future research. Development processes typically followed iterative cycles of prototype development, user testing, feedback collection, and system refinement. Attention and engagement improvements were also reported, with Chinchay et al. observing reduced need for specialist interventions and improved task completion times following personalized attention strategy implementation. Usability assessment was explicitly reported in two studies using the System

Usability Scale. One application achieved an excellent usability score of 97/100, while another reported a good score of 77.5/100, both exceeding the standard SUS benchmark. Across studies, parents played a central role not only in supporting children during app use but also in reinforcing learned skills within daily home routines.

3.6 Reported Impacts (RQ4)

Eight studies implemented intervention-based applications and reported measurable outcomes for children with ASD. Percentages in this section are calculated based on these intervention studies only.

- Communication Skills (4 studies, 50% of intervention studies) Mobile applications improved children's ability to express needs and interact. Laubscher et al. reported an increase from 2 to 12 communication attempts per session (approximately 500% improvement) using video visual scene displays, with a large effect size ($\text{Tau-U} = 0.8$). The study also found that picture-based communication did not reduce natural speech. Rojas and Chavarriaga observed improvements in self-expression and task completion, while Purnama et al. reported positive feedback from children, parents, and therapists.
- Emotional and Behavioral Control (3 studies, 38%) Applications supported emotion recognition and stress awareness. Yap et al. demonstrated improved emotion recognition using training activities and heart-rate monitoring. Kalantarian et al. achieved accuracy rates between 81% and 94% using machine learning for facial emotion detection (Disgust 94%, Surprised 92%, Neutral 81%). Visual schedules developed by Rojas and Chavarriaga also

helped reduce anxiety by increasing predictability.

- Daily Living Skills (3 studies, 38%) Apps supported independence in daily routines. Mruzek et al. found that a toilet-training application required significantly less daily training time compared with traditional methods ($p = 0.02$) while achieving similar learning outcomes, with 84% skill retention after 12 weeks. Additional improvements were reported in dressing and hygiene routines, along with reduced therapist workload.
- Parent Satisfaction (5 studies, 62%) Parents reported high satisfaction with mobile interventions. Usability scores reached 97/100 in the study by Rojas and Chavarriaga and 77.5/100 in Shminan et al. In the study by Mruzek et al., approximately half of parents reported being "very satisfied." Parents particularly valued progress tracking, increased confidence in supporting their children, and reduced stress levels.

4. DISCUSSION

4.1 Key Findings and Limitations

This systematic review of 15 peer-reviewed studies indicates a clear shift in mobile application development for children with autism spectrum disorder toward integrated, theory-driven interventions combining therapeutic frameworks with interactive and adaptive technologies. User-Centered Design was reported in about one-quarter of the studies (27%), while structured therapeutic approaches such as Applied Behavior Analysis (20%), TEACCH (13%), and PECS (13%) were incorporated to support learning, communication, and daily functioning.

Table 6 Technology features and technical specifications.

No.	Platform	Input / Output	AI/Adaptive features	Framework / Development tools	Connection type
1	Mobile apps (general)	N/A (Guidelines) / Multimedia (visual, audio, text, animation)	Recommendations for adaptive content	Literature synthesis, thematic analysis	Offline-first recommended
2	iOS, Android, Web	Touch, voice, gesture / Visual cues, audio feedback, rewards	Some apps use adaptive difficulty	Systematic review, app analysis framework	Varies (online/offline)
3	Android tablet	Touch / Visual schedules, step-by- step guides, rewards	Dynamic difficulty adjustment	Java/Kotlin, Android Studio, SQLite, MVC architecture	Offline
4	Android + smartwatch	Touch, camera (facial) / Visual emotion feedback, haptic alerts	Emotion recognition algorithms	Java, Android Studio, Bluetooth API, Client-server	Bluetooth
5	Android	Touch / Video tutorials, visual guides, progress tracking	Manual customization by caregivers	Java, Android Studio, SQLite, Modular design (3 modules)	Offline
6	Mobile (unspecified)	Camera (facial) / Emotion labels	ML-based emotion recognition (SVM, RF, NN)	Python, scikit-learn, TensorFlow, ML pipeline	Requires processing power
7	Android tablet	Touch, microphone / Visual/audio rewards, animations	DDA (Dynamic Difficulty Adjustment) algorithm	Unity C#, Game engine, Visual Studio	Offline
8	Android + iOS	Voice, microphone / Speech synthesis (TTS), PECS images	NLP for language processing	React Native, Python backend, Google Cloud Speech API, Cloud database	Cloud-based
9	AR devices (phones, tablets, smart glasses)	Touch, gesture, gaze / AR overlays, 3D objects, animations	Some reviewed apps use adaptive AR	VOSviewer, systematic review tools	Varies (camera-based AR)
10	Android tablet	Touch / Visual rewards, audio feedback	Manual difficulty selection	Android Studio, Java, graphic design tools	Offline
11	iPad (GoVisual app)	Touch (hotspots on videos) / Speech output, video playback	Videos customizable by therapist	iOS (Swift/Objective-C), GoVisual app, video editing	Offline
12	Smartphone (iOS/Android)	Camera (video), touch / Real-time feedback, emotion labels	ML classifiers (CNN, SVM)	React Native, Python, scikit- learn, TensorFlow, Cloud storage	Online (crowdsourcing)
13	Android mobile app	Touch input / Contextual picture cards	Context-aware content adaptation (location-based)	React Native, Android Studio, PECS framework, UCD	Online (context/location AP
14	Android + Web (React)	Touch / ABA exercises, video, rewards	Adaptive therapy content based on progress	Unity, React, ABA protocols, Double Diamond HCD	Online + Offline
15	Android tablet (Samsung Galaxy Tab S4)	Touch / Visual timers, audio cues, animations	Personalized attention configurations (inactivity timer, difficulty)	Web technologies (HTML/CSS/JS), multiple- baseline design	Offline

focused tools to multifunctional applications addressing emotional regulation, attention, independence, and daily living skills, often involving caregivers in home-based intervention contexts. Artificial intelligence and adaptive mechanisms were present in approximately 9 studies (60%), mainly for emotion recognition, personalization, and adaptive learning. Android emerged as the most commonly used platform, followed by iOS and cross-platform solutions.

CASP quality assessment indicated moderate methodological rigor, with an average score of 6/8 and 47% of studies rated as high quality. However, several limitations were evident: 71% of studies with real user samples (10 of 14) involved fewer than 30 participants, 79% were conducted over short intervention durations of under eight weeks, and most lacked comparison groups or longitudinal evaluation. Overall, the field is progressing toward user-centered and adaptive intervention models, yet significant gaps remain in long-term effectiveness, comparative validation, and real-world implementation. Future research should prioritize rigorous experimental designs, multi-site trials, and standardized outcome measures to strengthen the evidence base.

4.2 Limitations of This Review

This review has several limitations. First, although two databases were used (Scopus and IEEE Xplore), full-text access in IEEE Xplore was restricted to only 4 of 40 identified records, which may have resulted in the exclusion of relevant studies indexed in other databases such as PubMed, Web of Science, or PsycINFO, although Scopus provides broad multidisciplinary coverage. In addition, only English-language publications were included, which may have excluded potentially relevant research conducted in other languages.

Second, the heterogeneity of the included studies limited direct comparison and prevented meta-analysis or pooled effect size calculation. The studies varied considerably in research design, sample size, intervention duration, and outcome measures, ranging from single-case studies to randomized controlled trials, and from single-session evaluations to interventions lasting up to 12 weeks.

Third, this review did not evaluate the technical quality, data security, or privacy practices of the included applications, which are critical considerations for real-world implementation, particularly for pediatric populations. Cost-effectiveness analysis was also beyond the scope of this review.

Additionally, potential publication bias may exist, as studies reporting negative or non-significant findings are less likely to be published. This may lead to an overestimation of the effectiveness of mobile interventions for children with ASD.

4.3 Future Directions

Future research should prioritize longitudinal evaluations, standardized usability assessments, and stronger collaboration between clinicians, developers, and caregivers to enhance effectiveness and real-world applicability. Studies with larger sample sizes ($n > 100$), randomized controlled designs, active comparison groups, and long-term follow-up periods of at least 6–12 months are needed to produce stronger evidence. Greater geographic and cultural diversity is also essential. Future work should include low- and middle-income countries, culturally diverse populations, and the development of culturally adapted interventions that reflect different family values and care practices. Data privacy and security require urgent attention. Since mobile applications often collect sensitive data such as videos, photos,

and behavioral records of children, future research should establish clear privacy frameworks, encryption standards, and ethical guidelines tailored for pediatric digital health tools. Emerging technologies present additional opportunities. Future studies may explore virtual reality for social skills training, wearable sensors for physiological monitoring, and voice-based interfaces for more natural interaction. Machine learning models should also be validated across diverse populations to reduce bias and ensure equitable performance across different user groups.

5. CONCLUSION

This systematic literature review synthesized 15 peer-reviewed studies published between 2018 and 2025 on mobile application development for children with Autism Spectrum Disorder, following PRISMA guidelines and dual-database searches. The findings demonstrate a clear evolution in mobile autism intervention technologies toward integrated, user-centered, and adaptive solutions. Eight studies involved user-based intervention or evaluation, all reporting positive outcomes across multiple developmental domains, including communication (4 studies), emotional regulation (3 studies), attention (2 studies), and daily living skills (3 studies).

Applications integrating therapeutic frameworks such as Applied Behavior Analysis, TEACCH, and PECS with user-centered design approaches were consistently associated with improved usability and intervention outcomes. Recent studies also introduced technological innovations, including context-aware communication systems, home-based intervention platforms supporting caregiver participation, and adaptive applications targeting attention and autonomy. These developments reflect a shift from clinic-centered tools toward

more holistic and ecologically valid interventions embedded within everyday environments.

Contribution to the Literature

This review advances the existing literature in three primary ways. First, it focuses exclusively on peer-reviewed primary research studies and applies structured quality appraisal using the CASP framework, moving beyond descriptive reviews of commercially available applications toward evidence-based evaluation of development approaches and intervention outcomes.

Second, the integration of technical and interdisciplinary sources enabled the identification of emerging methodological innovations, including adaptive systems, personalized intervention models, and context-aware application design, which are often underrepresented in traditional health-focused reviews.

Third, this review explicitly examines the relationship between development methodologies and reported outcomes, highlighting the importance of participatory design, stakeholder engagement, and therapeutic grounding in improving usability and intervention effectiveness.

Comparison with Previous Reviews

The findings both corroborate and extend prior systematic reviews. Previous work has highlighted the rapid growth of autism-related mobile applications and the predominance of communication-focused tools; however, this review demonstrates a broader shift toward multifunctional interventions addressing emotional, behavioral, and daily living domains.

Consistent with earlier reviews, methodological limitations remain evident across the field, including small sample sizes, short intervention durations, and limited longitudinal evaluation. In the present review, 71% of studies with real user samples involved fewer than 30 participants, 79% of studies

reporting intervention duration were conducted over short-term periods, and only one study included follow-up assessment beyond the intervention phase. These patterns suggest that, despite technological advances, the empirical evidence base remains at an early stage of development. Implications for Research and Practice

For researchers, the findings highlight the need for more rigorous evaluation designs, including larger samples, comparison conditions, and longitudinal assessment of intervention outcomes. The recurring association between stakeholder involvement and improved usability outcomes suggests that participatory and user-centered development approaches should be considered essential components of autism technology design.

For practitioners and caregivers, the review underscores the importance of selecting empirically validated applications rather than relying solely on commercially popular tools lacking research support. The emergence of home-based intervention platforms indicates strong potential for technology to improve accessibility and continuity of care, particularly outside clinical settings.

Final Remarks

Mobile applications demonstrate considerable promise for supporting children with autism spectrum disorder across communication, emotional, behavioral, and daily functioning domains. However, realizing this potential requires sustained commitment to rigorous research methodologies, interdisciplinary collaboration, and long-term evaluation of real-world implementation. By synthesizing current evidence and identifying critical methodological gaps, this review provides a foundation for advancing both research and practice in technology-mediated autism intervention and supports the development of

more effective, accessible, and evidence-based digital tools for children with autism.

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