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# A REVIEW OF AI-DRIVEN APPROACHES IN AUTISM EDUCATION

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## ABSTRACT

Artificial Intelligence (AI) is increasingly recognized as a transformative force in education, offering tailored, adaptable, and accessible tools for neurodiverse learners, particularly autistic students. Despite this potential, there remains limited consolidated knowledge on how AI technologies are currently being applied in autism education and what challenges persist. This paper addresses that gap by surveying and synthesizing recent developments in the field. The objective of this study is to examine current trends in AI applications for autistic learners and to identify both opportunities and limitations. To achieve this, a systematic search of major academic databases was conducted, covering publications between 2021 and 2025. The study selection process adhered to PRISMA-style reporting guidelines, ensuring transparency, reproducibility, and methodological rigor. Following screening and eligibility assessment, fifteen peer-reviewed articles were included for analysis. This study conducted a thematic analysis of fifteen peer-reviewed articles using Braun and Clarke's six-phase framework. The analysis revealed four major themes: (1) AI modalities, highlighting the range of technologies employed; (2) educational domains, specifying the areas of learning targeted; (3) implementation settings, describing the contexts in which these technologies are deployed; and (4) reported gaps, outlining the limitations and challenges documented in the literature. The findings suggest that future research should prioritize the development of ethically grounded, culturally relevant, and neurodiversity-affirming AI applications. Long-term validation, sensitivity to cultural contexts, and scalability across diverse educational settings are essential to ensure that AI innovations genuinely enhance learning and communication for autistic children.

## Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder with a complicated nature. The core features of the disorder mainly include issues with social communication, the presence of heavily focused interests, and repetitive behaviours. Generally, these essential signs of the disorder hamper not only the child's getting admission to school and their academic performance but equally are the reasons for an increase in emotional and behavioural problems and, through bullying, possibly triggering social isolation (Habibi et al., 2025). Because of these features, different learning profiles arise which are in need of an individualised educational support system. However, the normal school system does not show enough flexibility to be able to cater to the cognitive, sensory, and communication needs of autistic students which are typical (Li et al., 2024). Even though culture and socioeconomic status influence a child's learning style, they are often ignored, thus resulting in the learner's disengagement and poor academic performance (Adako et al., 2024).

AI technologies were developed to address such issues and have since become great tools for delivering personalised, adaptive, and efficient interventions. Many recent papers have described AI's ability to dramatically change the way children with autism are educated by providing them with support for engagement, communication, and individualised learning outcomes (Adako et al., 2024; Barua et al., 2022; Kotsi et al., 2025). The purpose of this review is not only to compile the existing materials while at the same time gaining insight into the current weighting of AI technologies in autism education. By examining the modalities employed, the domains they target, the settings in which they are implemented, and the limitations reported, this study seeks to identify emerging trends and highlight areas where future research can make a meaningful impact. Consequently, the review will help educators, researchers, and policymakers to get a clear idea as to how AI may be used to help autistic learners in an efficient as well as culturally sensitive manner.

## Material and Methods

### *Search Strategy*

This paper focuses on reviewing the implementation of AI technologies for autism education based on recent scholarly articles. Investigators systematically searched academic databases for works published in 2021-2025. Boolean keyword combinations were used for searching the literature, including words ("Artificial Intelligence" OR "AI" OR "Machine Learning" OR "Natural Language Processing" OR "Educational Robotics") AND ("Autism" OR "Autistic Children" OR "ASD" OR "Neurodiverse Learners") AND ("Education" OR "Learning" OR "Teaching" OR "Special Education" OR "Inclusive Education"). The paper inclusion process was based on PRISMA guidelines to guarantee the clarity, reproducibility, and methodological rigor of the research

Once the search was complete, the data collection was read, and important points related to using AI for autism education were taken out. A screening process with multiple layers was utilized: initially, the sets of inclusion and exclusion criteria (Table 1) were employed to determine the papers' relevance, which was then followed by cleaning the data where the duplicates, non-accessible documents, and irrelevant data points were removed. Eventually, the result of this process was a set of fifteen researched papers fully analysed.

To maintain transparency in methodology, a search strategy based on the redecided set of inclusion and exclusion criteria was used. The qualified papers were those that appeared in journals or conferences, went through the peer-review process, and comprised of journal articles and conference proceedings published within the date range 2021-2025, were written in English, and whose full-text version was available. The research papers were considered for the review only if they presented the authors' work on the application of AI technologies such as natural language processing, machine learning, robotics, adaptive systems, or expert systems to teaching autistic children or neurodiverse learners. The excluded items were non-peer-reviewed sources, non-English literature, inaccessible full-texts, and papers unrelated to autism, AI, or education.

Thematic analysis of the gathered papers was done through Braun and Clarke's (2006) six-phase thematic analysis framework. This approach involved familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report.

**Table 1:** Inclusion and Exclusion Criteria for Literature Selection

| Criteria Type | Inclusion Criteria | Exclusion Criteria |
|---|---|---|
| **Publication Type** | Peer-reviewed journal articles and conference proceedings | Editorials, opinion pieces, book chapters, theses, and unpublished manuscripts |
| **Publication Date** | Published between 2021 and 2025 | Published before 2021 or after 2025 |
| **Language** | English | Non-English publications |
| **Focus Area** | Studies involving AI technologies applied to autism education | Studies unrelated to autism, AI, or educational contexts |
| **Population** | Research involving autistic children or neurodiverse learners | Studies focused solely on adults or non-autistic populations |
| **Technology Scope** | AI modalities (e.g., NLP, ML, robotics, adaptive systems, expert systems) | Non-AI technologies (e.g., traditional tools, general ICT without AI components) |
| **Educational Context** | Formal or informal learning settings (e.g., school, home, therapy, digital platforms) | Clinical-only studies with no educational component |
| **Accessibility** | Full-text available | Abstract-only or inaccessible full-text documents |

The study selection process used PRISMA-style reporting in order to guarantee the transparency, reproducibility and methodological rigor. In total, 222 records were first retrieved from twelve main academic databases, namely, IEEE Xplore®, Scopus®, ScienceDirect, SAGE Journals, Springer Nature, Web of Science™, MDPI, Applied and Computational Engineering, ARXIV, Technium Social Sciences Journal, ACM Digital Library, and IJBTCM. After the removal of 70 duplicate records, there were 152 unique records left for screening based on their titles and abstracts. From these, 102 records were rejected as per the predefined criteria such as book chapters, theses, unpublished manuscripts, studies focused solely on adults, clinical-only studies, abstract-only records, and inaccessible full-text documents. A total of 50 full-text articles were left for eligibility check. Consequently, 35 studies were excluded as the technologies used were non-AI or general ICT tools without AI components. Ultimately, 15 studies that fulfilled all the inclusion criteria became part of the final synthesis. This process is visually summarized in Figure 1, which presents the PRISMA flow diagram of study identification, screening, and inclusion.

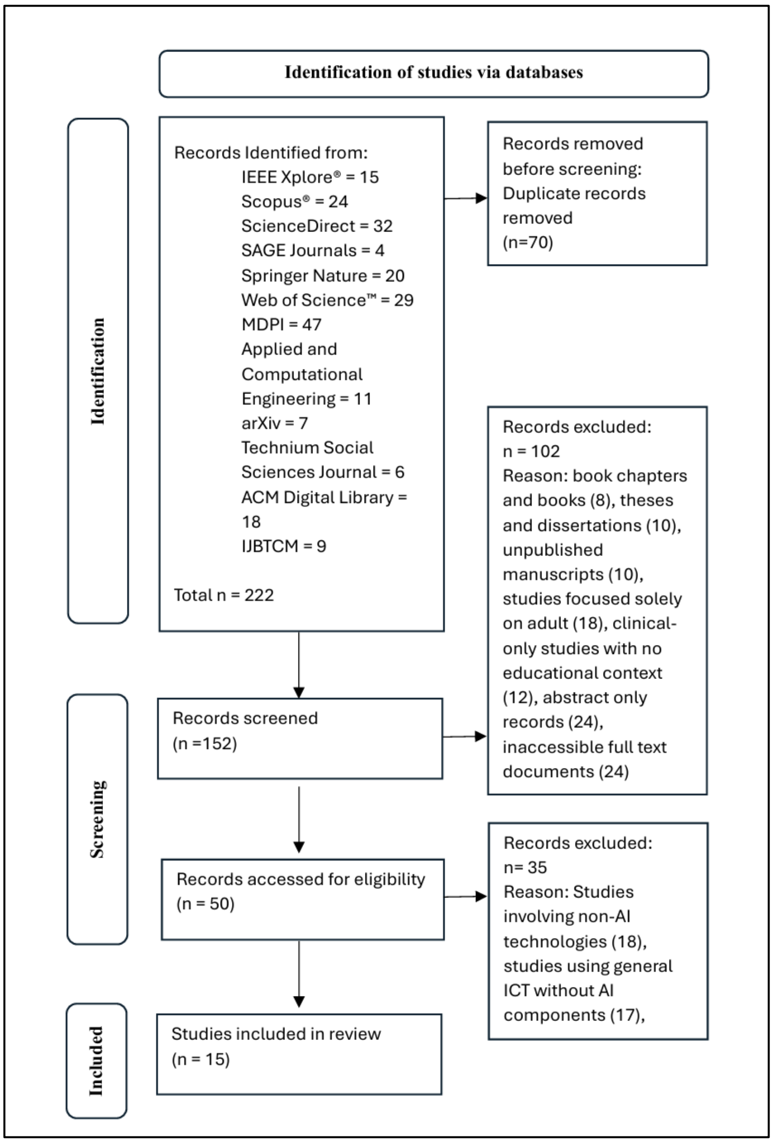


**Figure 1:** PRISMA Flow Diagram

***Quality Assessment***

After the PRISMA flow diagram (Figure 1) and the eligibility criteria set out in Table 1, the 15 studies that were included in the final synthesis have been subjected to a formal quality appraisal. The review was based on the well-known critical appraisal principles for educational and technology-enhanced research, which focused on the clarity of the aims, the appropriateness of the AI methodology, the relevance to autism education, the transparency of data collection and analysis, the ethical considerations, and the completeness of reporting.

Several studies have shown different strengths in methodology used in the research on AI in autism education. Gu (2023) explored how intelligent tutoring systems and social robots can be integrated in therapy through using strong computational models to improve adaptive learning outcomes. In the same way, Lyu et al. (2024) created AI-based games for social-emotional learning that merged affective computing with game interaction to encourage engagement and emotional regulation in kids with autism.

Among other things, Jiang (2021) reviewed AI robots in autism education, thus exposing their possibilities for communication and social interaction training. In the same vein, Sideraki and Drigas (2021) gave a comprehensive account of AI advances in autism, which merely served as a background to their scarce empirical results. El Shemy (2022) researched the integration of mobile augmented reality with AI for language learning and came up with novel uses of such technologies for school education. On the other hand, Priyadarshini, et al. (2024), through their work on AI-based emotion detection with MATLAB, shed light on the potential of the early detection of socio-emotional issues from the public health perspective.

Two papers, Athbah (2024), which evaluated teachers' views on robotics for social skill development, and Valentim et al. (2024), which used AI to improve joint attention in autistic learners, highlighted practical challenges and inclusivity issues in the educational adoption of their solutions. Lemaignan et al. (2021) progressed UNICEF's policy on AI for children by creating social robots in collaboration with autistic learners, and Vanaja and Raj (2025) invented AI-powered IoT devices for emotional and social developmental support, thus both instances showcasing methodological innovation while deficient in full ethical reporting.

Meanwhile, Lan et al. (2024) came up with a public health model based on transformer for the study of social skill development, and Xing (2024) used AI for language and communication training. They both gave clear intervention designs but barely discussed how well they could be generalized. Sağdıç et al. (2024) investigated the use of generative AI and robots in inclusive special education, whereas Stasolla et al. (2024) wrote a paper on AI-based programs for autism therapy using virtual reality platforms. In spite of the fact that their results were encouraging, the constraints were due to the small number of participants in both studies. Lastly, Rêgo and Araújo-Filho (2024) performed a comprehensive review of AI applications for enhancing the quality of life of autistic learners. They had a thorough analysis but, in comparison with other works, methodological details were not as clearly presented.

Overall, all 15 studies have passed the minimum quality criteria necessary for their inclusion. The methodological rigor of the studies differed; however, each study was relevant and sufficiently transparent to be included in the thematic synthesis. The quality assessment was used to determine the evidential weighting of the themes, which implied that the interpretation of the findings took into account the strengths and weaknesses of the methodologies.

***Thematic Analysis (Braun & Clarke)***

To analyse patterns across the 15 selected literature, Braun and Clarke's (2006) six-phase framework for thematic analysis was employed. This involved familiarisation with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. Thematic analysis enabled the identification of recurring concepts and methodological gaps in the use of AI technologies for autism education. Figure 2 show the six-phase framework for thematic analysis adapted from Braun and Clarke's original framework.

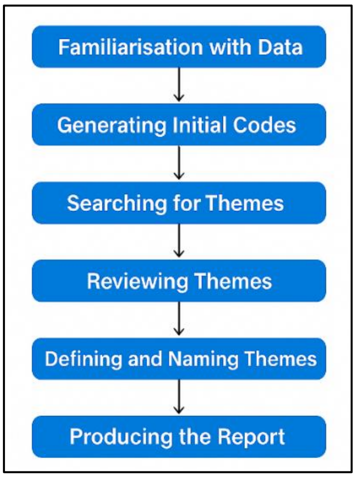


**Figure 2:** Six-phase framework for thematic analysis adapted from Braun and Clarke (2006).

### *Thematic Coding and Categorisation*

Thematic analysis was carried out, starting with acquainting and initial coding. Recurring ideas like "robotics," "adaptive learning", and "personalised learning" were identified throughout the studies included. These codes were thereafter organized into sets of related ideas through joint discussion, which facilitated the emergence of initial themes. The themes were checked to cover the data thoroughly and were smoothed out to get rid of repetition and conceptual overlap.

This back-and-forth method led to the four main dimensions being identified that essentially captured the conceptual focus of the reviewed literature: AI modalities, educational domains, implementation settings, and reported gaps. The dimensions represented separate analytical categories, and each was assigned a general term to give an idea of the extent of each characteristic. As evident from Table 2, AI modalities included various techniques such as NLP, ML, and RL; educational domains referred to fields such as communication skills, SEL, diagnosis, and personalised learning; implementation settings were the environments in which AI was used, i.e., home, school, clinic, and digital platforms; and reported gaps highlighted the most frequent limitations like cultural sensitivity, ethical concerns, and small sample sizes. This structured categorization offered a uniform analytical perspective through which the studies were integrated, hence uncovering thematic patterns and methodological trends across the literature.

**Table 2:** Thematic dimensions of AI application in autism education.

| Dimension | Definition | Example Codes |
|---|---|---|
| AI Modalities | Type of AI technique used | Natural Processing Language (NLP), Machine Learning (ML), Reinforcement Learning (RL), etc |
| Educational Domains | Targeted learning or developmental area | Communication Skill, Socially Emotional Learning (SEL), Diagnosis, Personalized Learning, etc |
| Implementation Settings | Context where AI was applied | Home, School, Clinic, Digital Platform, etc |
| Reported Gaps | Recurring gaps / limitations identified across studies | Cultural Sensitivity, ethical concerns, small sample sizes, etc |

### *Thematic Mapping of Reviewed Studies*

This review was intended to identify recurring patterns among the studies reviewed and to summarize the findings. First of all, it would make a comparison of the trends of AI technology in autism education more structured. The outcomes of the coding exercise, summarised in Table 3, represent a matrix display of the degree to which each paper corresponds to the four main thematic dimensions: AI modality, educational domain, implementation setting, and reported gaps. This tabular synthesis allows multidimensional analysis and reveals the joint contribution of the literature to the general thematic framework. Each study has been mapped against these dimensions, showing review transparency in interpretation and the provision of a uniform analytical lens for subsequent thematic synthesis.

**Table 3:** Matrix of reviewed studies mapped against four thematic dimensions.

| No. | Author(s) | Year | AI Modality | Educational Domain | Implementation Setting | Reported Gaps |
|---|---|---|---|---|---|---|
| 1 | Gu | 2023 | ✓ | ✓ | ✓ | ✓ |
| 2 | Lyu et. al. | 2024 | ✓ | ✓ | ✓ | ✓ |
| 3 | Jiang et. al. | 2021 | ✓ | ✓ | ✓ | ✓ |
| 4 | Sideraki & Drigas | 2021 | ✓ | ✓ | ✓ | ✓ |
| 5 | El Shemy | 2022 | ✓ | ✓ | ✓ | ✓ |
| 6 | Priyadarshini et al | 2024 | ✓ | ✓ | ✓ | ✓ |
| 7 | Athbah | 2024 | ✓ | ✓ | ✓ | ✓ |
| 8 | Lemaignan et al. | 2021 | ✓ | ✓ | ✓ | ✓ |
| 9 | Lan et al. | 2024 | ✓ | ✓ | Not Specify | ✓ |
| 10 | Vanaja & Raj | 2025 | ✓ | ✓ | ✓ | Not Specify |
| 11 | Xing | 2024 | ✓ | ✓ | Not Specify | ✓ |
| 12 | Valentim et al. | 2024 | ✓ | ✓ | Not Specify | ✓ |
| 13 | Sağdıç et al. | 2024 | ✓ | ✓ | Not Specify | ✓ |
| 14 | Stasolla et al | 2024 | ✓ | ✓ | ✓ | ✓ |
| 15 | Rêgo & Araújo-Filho | 2024 | ✓ | ✓ | ✓ | ✓ |

## Results and Discussions

The use of AI technologies in the education of autistic children has been the focal point of recent studies, which increasingly evaluate the moral and practical issues of using these systems in the educational environment of neurodiverse children. The papers that are summarized here illustrate the various AI applications that have been adapted and implemented within the teaching of ASD children.

This review, however, extends to a conceptual framework that will usher in the next phase of research. The framework not only places AI modalities as instruments targeting certain educational areas, but also spans the different implementation sites where such tools are used and looks at the common methodological and practical gaps as the criteria for evaluation. The model is, however, a cultural and Islamic one that integrates ethical norms, inclusivity and sensitivity to contexts. The framework thus not only boosts the rigor of the methods but also guarantees that the use of AI technologies in the teaching of autism will be socially responsive and culturally sensitive among the diverse learner's needs.

### *AI Modalities in Autism Education*

Table 4 shows a mapping of different AI modalities used in fifteen studies regarding the use of AI technology in autism education. All 15 studies refer to the use of AI technologies, with several studies employing more than one modality. Commonly used techniques included Natural Language Processing (NLP), Machine Learning (ML), Socially Assistive Robotics (SAR), Computer Vision (CV), Reinforcement Learning (RL), Augmented Reality (AR) & Virtual Reality (VR), Expert Systems, and Affective Computing (AC).

**Table 4:** AI modalities employed in autism education (2021–2025)

| No. | Author(s) | Year | AI Modalities | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | NLP | ML | CV | SAR | AR/VR | Expert System | RL | AC |
| 1 | Gu | 2023 | ✓ | ✓ | | | | | ✓ | |
| 2 | Lyu et al. | 2024 | | | ✓ | | | | | ✓ |
| 3 | Jiang et al. | 2021 | ✓ | ✓ | ✓ | ✓ | | | | ✓ |
| 4 | Sideraki & Drigas | 2021 | ✓ | ✓ | | ✓ | ✓ | ✓ | | |
| 5 | El Shemy | 2022 | | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| 6 | Priyadarshini et al | 2024 | | ✓ | | | | | | ✓ |
| 7 | Athbah | 2024 | ✓ | ✓ | | | | ✓ | ✓ | |
| 8 | Lemaignan et al. | 2021 | | | | ✓ | | | | ✓ |
| 9 | Lan et al. | 2024 | ✓ | ✓ | ✓ | | | | | ✓ |
| 10 | Vanaja & Raj | 2025 | | ✓ | ✓ | | | | | ✓ |
| 11 | Xing | 2024 | ✓ | ✓ | | ✓ | | | | |
| 12 | Valentim et al. | 2024 | | ✓ | | | | ✓ | | |
| 13 | Sağdıç et al. | 2024 | | | | ✓ | | | | |
| 14 | Stasolla et al | 2024 | | ✓ | | | | | | |
| 15 | Rêgo & Araújo-Filho | 2024 | ✓ | ✓ | ✓ | ✓ | | ✓ | | |

From the result of the analysis, Figure 3 shows that ML (25.5%) represents the highest number of instances of AI usage in autism educational research. ML algorithms are widely applied in adaptive learning systems and diagnostic modeling (Gu, 2023; Athbah, 2024; Priyadarshini et al., 2024). Several studies have explored deep learning approaches, particularly recurrent neural networks (RNNs), to process multimodal data such as language, actions, facial expressions, and brain imaging. These methods are claimed to enhance personalization and improve intervention accuracy (Jiang et al., 2021; Lan et al., 2024). For example, Sideraki and Drigas (2021) used EEG signals together with ML techniques and the multiscale entropy (mMSE) algorithms for profiling cognition and emotion. In the same way, machine learning has been a major tool for creating behavioral models that allow personalized care and facilitate the extension of these models to real-world situations (El Shemy, 2022; Xing, 2024). But, still, the majority of these studies were conducted with small-scale samples and no control groups; consequently, the strength of their claims was rather weak. On top of that, although authors repeatedly asserted that personalization and diagnostic accuracy were enhanced, only a few studies brought validation of the outcome measures, hence making it hard to tell the good from the bad in terms of potential and empirically verified performance.

NLP (14.9%) and AC (14.9%) are tied in frequency. NLP has been employed in systems such as the Lana platform (Gu, 2023) and integrated into robotic platforms and voice assistants to facilitate speech recognition and interactive communication (Jiang et al., 2021; Athbah, 2024). It also underpins chatbots and conversational agents designed to support emotional expression and social interaction (Sideraki & Drigas, 2021). AC's main goal is to detect and react to the students' emotions with the help of their body signals like EEG and heart rate variability (HRV) (Priyadarshini et al., 2024). In a study, Lemaignan et al. (2021) showed that AC can help through emotional control by adaptive interactions, while Lan et al. (2024) were able to detect feelings based on the speech traits and facial expressions. Although these approaches highlight the promise of emotionally responsive learning environments, validation remains limited. Many studies reported positive engagement outcomes, but few employed standardized psychological or educational assessments, raising concerns about generalizability and the gap between claimed emotional responsiveness and verified learner improvement.

SAR and CV, each accounting for 12.8%, play important roles in supporting interaction and visual learning. SAR is about humanoid, non-humanoid, and animal-shaped robots created to be able to teach social skills (Jiang et al., 2021). Robots such as NAO, Kaspar, and Lego-based ones have been applied in teaching communication skills and emotional control (Sideraki & Drigas, 2021). Among the CV applications are facial recognition, eye-gaze tracking, and behavioral modeling (Athbah, 2024; Jiang et al., 2024) which help in developing emotional and social skills (El Shemy, 2022). Lyu et al. (2024) used the recognition of facial expressions in playful environments for the purpose of easement of the fear of emotions understanding. However, the versatility indicated by these studies is mostly attributed to their production in very controlled environments with a small number of participants, which leaves the issues of scalability and ecological validity open for discussion. The supposed advantages of better social interaction are quite alluring, but the actual results have not been so clear-cut and up to now, the proof of improvements being maintained has been given by only a few longitudinal studies.

Expert systems (10.6%) function as rule-based decision support tools guiding clinical and educational interventions. Diagnostic decision-making has been one field where they were applied (Rêgo & Araújo-Filho, 2024), as well as adaptive learning environments (Valentim et al., 2024), and educational strategy planning (Athbah, 2024; El Shemy, 2022). Expert systems, though, present clear-cut assistance, but these systems are not as adaptable since they are limited by the rules set in their design, and moreover, the validation of such systems in varying educational contexts is not abundant. Reported improvements in diagnostic accuracy and learning personalization are largely claimed rather than empirically verified. Finally, RL (4.3%) and AR/VR (4.3%) remain underexplored. Gu (2023) illustrated RL in ITS to enhance adaptability, while AR/VR has been used in immersive environments for skill training (Sideraki & Drigas, 2021). These technologies are at an early stage, with only two studies referencing them, and both relying on pilot implementations without control groups or standardized validation. Their claimed potential for immersion and adaptability is compelling, but empirical evidence remains limited.

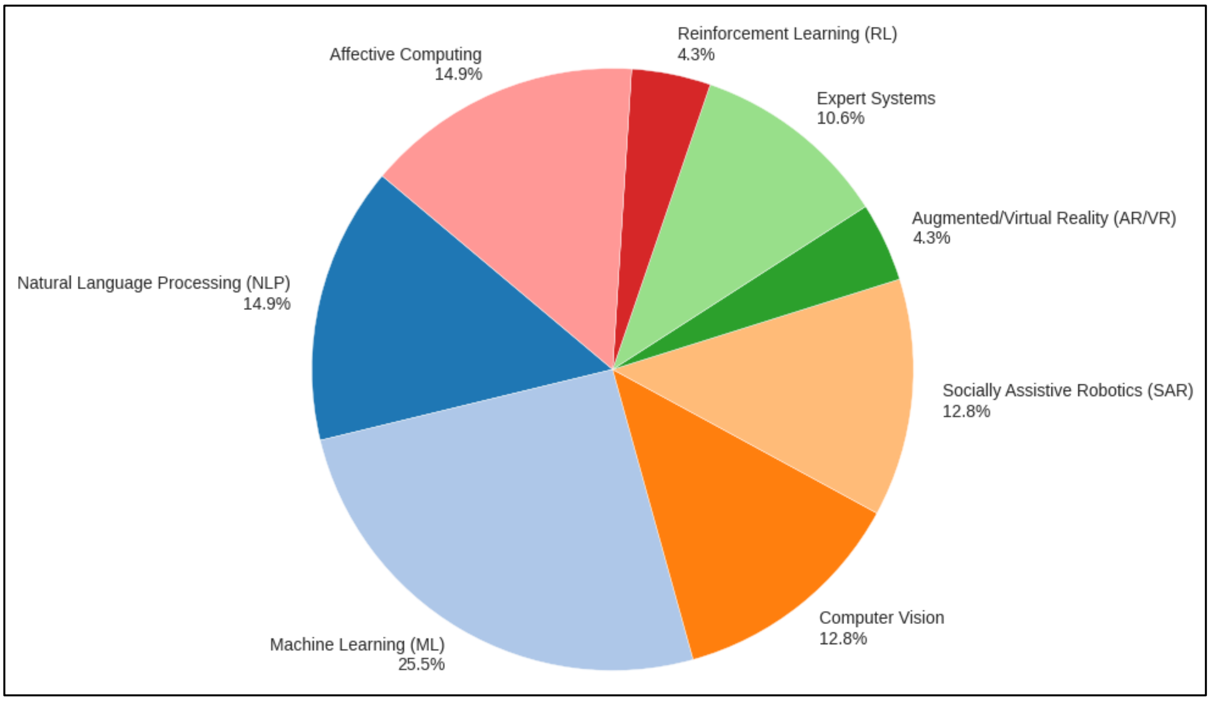


**Figure 3:** Distribution of AI technologies used in autism education (2021–2025)

### *Educational Domains Targeted by AI Technologies for Autism Education*

Table 5 synthesizes the educational domains targeted by AI technologies across fifteen studies. Communication and social interaction skills were ranked as the most common through thirteen out of the fifteen research papers in seven distinctive areas. As the most significant category, this pointed the way to the essential need for AI interventions to help in the development of expressive and receptive language—still a problem in the communication process with many autistic learners in the long run. On the other hand, Gu (2023) using social robots and ITS as an example, made emotional expression and interpersonal communication easier for the children with autism. Equally, Jiang et al. (2021) working on through AI-mediated interventions the very basic social behaviours like recognizing facial expressions, making eye contact, imitating, communicating verbally, and cooperating were the goals. Sideraki and Drigas (2021) went on to reveal that the use of robotics-integrated programs has been very successful in teaching and improving communicative and linguistic skills in autistic children too.

AI modalities NLP and SAR were the primary tools employed to support communication, social engagement, and interaction modeling, particularly in understanding behavioral and performance contexts (Gu, 2023; Jiang et al., 2021; Athbah, 2024; Lemaignan et al., 2021; Sağdıç et al., 2024; Sideraki & Drigas, 2021; Lan et al., 2024; Priyadarshini et al., 2024). Through these technologies, autistic learners can develop both receptive and expressive language skills, while also improving emotional expression and interpersonal interaction—areas that remain central challenges in autism education.

**Table 5:** Educational Domains Targeted by AI Technologies in Reviewed Studies (2021–2025)

| No. | Author(s) | Year | Educational Domains | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | **Comm. & Social Interaction Skills** | **Personalize Learning** | **Social Emotion Learning (SEL)** | **Diagnosis & Evaluation** | **Sensory Motor Training** | **Behaviour Training** | **Cognitive Development** |
| 1 | Gu | 2023 | ✓ | ✓ | | | | | |
| 2 | Lyu et. al. | 2024 | | ✓ | ✓ | | | | |
| 3 | Jiang et. al. | 2021 | ✓ | | | ✓ | ✓ | | |
| 4 | Sideraki & Drigas | 2021 | ✓ | ✓ | ✓ | ✓ | | | |
| 5 | El Shemy | 2022 | ✓ | | ✓ | | | | |
| 6 | Priyadarshini et al | 2024 | ✓ | ✓ | ✓ | | | | ✓ |
| 7 | Athbah | 2024 | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ |
| 8 | Lemaignan et al. | 2021 | ✓ | | ✓ | | | ✓ | |
| 9 | Lan et al. | 2024 | ✓ | ✓ | ✓ | | | ✓ | |
| 10 | Vanaja & Raj | 2025 | ✓ | ✓ | ✓ | | | | ✓ |
| 11 | Xing | 2024 | ✓ | ✓ | | ✓ | ✓ | | |
| 12 | Valentim et al. | 2024 | ✓ | | | | | | ✓ |
| 13 | Sağdıç et al. | 2024 | ✓ | ✓ | | ✓ | | | |
| 14 | Stasolla et al | 2024 | ✓ | ✓ | | | | ✓ | ✓ |
| 15 | Rêgo & Araújo-Filho | 2024 | | | ✓ | ✓ | | | |

As illustrated in Figure 4, the distribution of educational sectors receiving the attention of AI technologies is very much in line with the studies' thematic focus - the latter being the fifteen studies under review. The graph indicates that social interaction skills (26.5%), personalized learning (20.4%), and social-emotional learning (18.4%) are together accounted for as the topmost three domains—this corresponds with the research in these fields both in terms of frequency and depth. So, to say, ten studies dealt with personalised learning, using ML techniques to forecast learner preferences, adjust instructional content, and keep track of engagement (Lan et al., 2024; Sağdıç et al., 2024). Likewise, thirteen studies placed major focus on communication and social interaction, thus revealing the significance of AI tools like NLP and SAR in the development of expressive and receptive language (Gu, 2023; Jiang et al., 2021; Athbah, 2024).

The chart also shows that there has been very little interest in diagnosis and evaluation (12.2%), behavioral training (10.2%), and cognitive development (10.2%), which were discussed in six, four, and five studies respectively. ML, CV, and NLP were the AI modalities most commonly used in these areas to automate the diagnostic process and to support executive functions and behavioral modeling (Xing, 2024; El Shemy, 2022; Vanaja & Raj, 2025). However, diagnostic claims hardly ever included serious benchmarks against conventional clinical tools, while behavioral modeling studies frequently depended on short-term pilot trials without longitudinal follow-up. Thus, even though the authors stated that the improved diagnostics and behavioral regulation had been verified, the performance was still restricted to a few studies that could not demonstrate reproducible outcomes across different populations. Sensory-motor training (2.0%) was, finally, the least represented domain, with merely two studies probing AI-driven techniques for sensory engagement and motor coordination (Jiang et al., 2021; Xing, 2024). These studies, even though they reported possible benefits in relieving sensory and motor difficulties, both used poorly defined tasks and lacked any kind of validation, making it impossible to tell whether the improvements were just for the moment or if they could not be seen outside of the controlled environment.

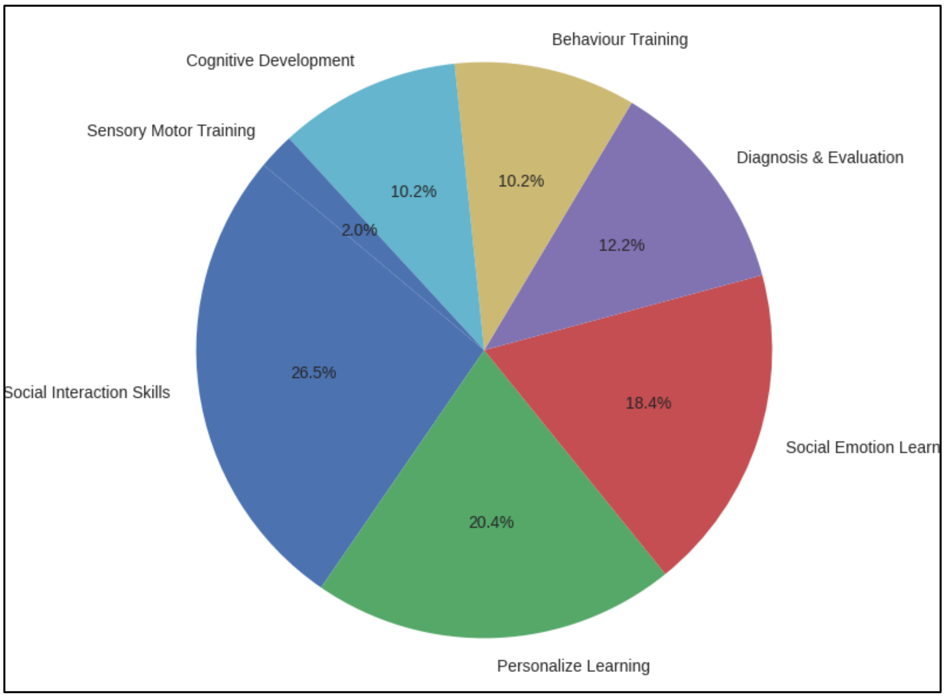


**Figure 4:** Distribution of Focus Areas in Autism Education Technologies (2021-2025)

### *Implementation Settings of AI Technologies for Autism Education*

Table 6 outlines the implementation settings in which AI technologies were applied across the fifteen studies reviewed. Of these, only eleven explicitly reported the settings in which AI was utilized. The home environment and therapeutic/clinical/rehabilitation settings were the two contexts most frequently mentioned, with over half of the studies each citing them. Gu (2023) emphasized the low cost and the possibility of using ITS independently in home environments and also recommended the blending of robots and ITS with traditional therapies such as Applied Behavior Analysis (ABA). Therapy sessions have, traditionally, been carried out in clinical or therapeutic environments. Jiang et al. (2021) mentioned the use of both clinical and home settings reporting that AI robots were integrated into the intervention and assessment processes. Sideraki and Drigas (2021) also talked about home-based therapy using AI-powered robots and virtual tools. All these findings point to the fact that the use of AI in autism therapy is gradually moving out of the conventional educational institutions with personalized, home-based, and carer-assisted settings gaining more and more attention.

**Table 6:** Implementation Settings of AI Technologies in Autism Education Across Reviewed Studies

| No. | Author(s) | Year | Implementation Settings | | | | |
|---|---|---|---|---|---|---|---|
| | | | Home Environment | Therapeutic / Clinical / Rehab Environment | Mobile/Virtual/Digital Apps Platform | School / Classroom | Research Laboratory |
| 1 | Gu | 2023 | ✔ | ✔ | | | |
| 2 | Lyu et al. | 2024 | ✔ | | ✔ | ✔ | |
| 3 | Jiang et al. | 2021 | ✔ | ✔ | | ✔ | |
| 4 | Sideraki & Drigas | 2021 | ✔ | ✔ | | ✔ | ✔ |
| 5 | El Shemy | 2022 | | | ✔ | | |
| 6 | Priyadarshini et al | 2024 | ✔ | ✔ | ✔ | | |
| 7 | Athbah | 2024 | ✔ | ✔ | ✔ | ✔ | |
| 8 | Lemaignan et al. | 2021 | | | | ✔ | |
| 9 | Vanaja & Raj | 2025 | ✔ | | | ✔ | |
| 10 | Stasolla et al | 2024 | | ✔ | | | |
| 11 | Rêgo & Araújo-Filho | 2024 | | ✔ | | | |

As depicted in Figure 5, the reviewed literature generally points to a growing interest in the distribution of implementation environments for AI technologies in autism education. The home environment (28.0%) and therapeutic/clinical/rehabilitation settings (28.0%) have been the most widely reported, each appearing in more than half of the studies. This indicates the increasing tendency of the personalized interventions and those with the support of the caregivers to be delivered outside the traditional school environments. For instance, Lyu et al. (2024) and Jiang et al. (2021) pointed out the importance of caregivers and therapists in the use of AI in the home and clinical settings, while Gu (2023) argued the cost-effectiveness and independence of the ITS for home use, also including their integration into therapies like ABA. Nevertheless, the studies were often based on small samples and did not employ control conditions which made it hard to discern whether the communication or independence gains were due to AI or the support provided by the caregivers. Authors cited improved personalization and cost-effectiveness but the confirmed outcomes remained scarce with only a few studies using standardized measures of therapeutic progress.

School/classroom environments (24.0%) were discussed in six studies, often in relation to robotics and AI tools used for structured learning and social interaction (Sideraki & Drigas, 2021). These settings support collaborative learning and are increasingly integrated with therapeutic approaches. Yet, most classroom-based studies were conducted in single schools or pilot programs, restricting generalizability. Claimed benefits such as improved peer interaction and structured learning were not consistently validated through longitudinal or comparative designs, leaving a gap between reported potential and verified educational outcomes.

Mobile, virtual, and digital platforms (16.0%) were featured in four studies, indicating a growing interest in remote and app-based interventions. El Shemy (2022) explored mobile AR applications deployed across home, school, and clinical contexts, highlighting their flexibility and accessibility. Even if the benefits of these platforms were said to be the opposite of better accessibility and engagement, they were again dependent on their long-term usability and validation data. A short-term increase in motivation or engagement would be reported by most studies but still absent was true evidence of learning gains being prolonged, hence the concerns about scalability and ecological validity were raised. Research laboratories (4.0%) were the least represented, finally, with only one study reporting their use for prototype testing and controlled experimentation (Sideraki & Drigas, 2021). Despite the fact that lab settings are very useful for technical refining, they have the same time the drawbacks of low ecological validity and lack of generalizability to the real-world applications. The performance that was claimed in controlled environments often was not transferred to verified outcomes in authentic educational contexts thus the need for field-based validation was highlighted.

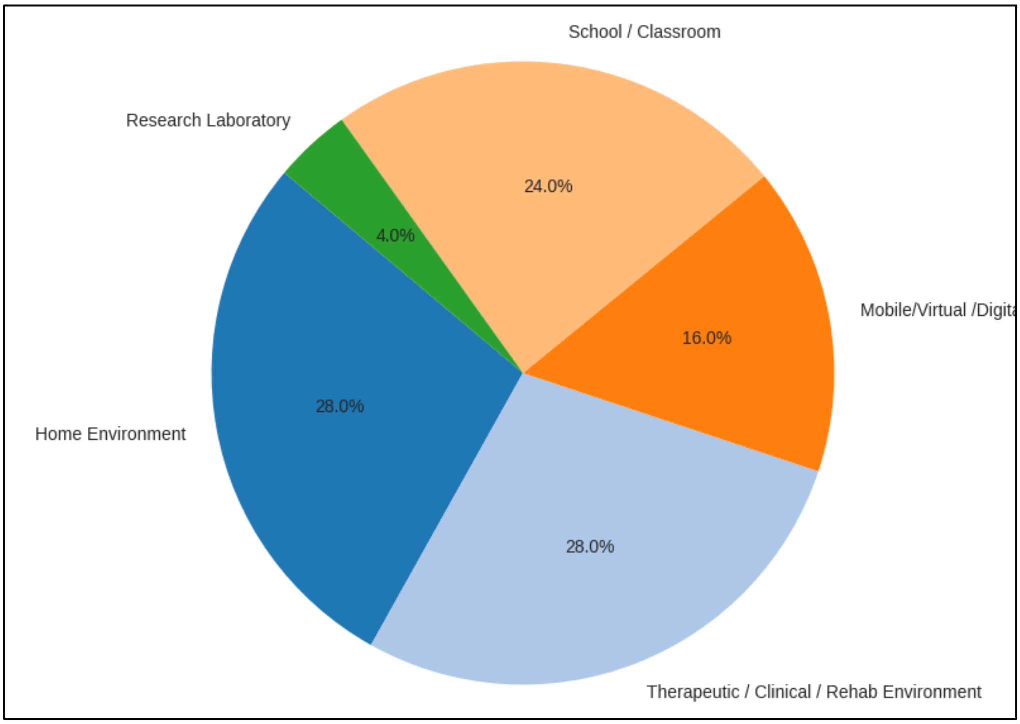


**Figure 5:** Distribution of Implementation Settings Across Reviewed Studies (2021-2025)

### *Reported Gaps and Limitations of AI Technology for Autism Education*

The twelve studies examined in this article have been shown to share the same shortcomings in empirical evidence, personalization and adaptivity, integration and scalability, ethical and privacy concerns, cultural and contextual gaps, and design and engagement as shown in Table 7. Thus, it is clear that the areas are of great concern for the future research and development of AI in autism educational applications. Most of the studies conducted did not have that kind of strong empirical validation, but rather they were mostly based on small sample sizes, short-term trials, or preliminary feasibility assessments. Clinical outcome measures were often ignored and longitudinal data were missing at several places in the most important publications of the past five years (Gu, 2023; Jiang et al., 2021; El Shemy, 2022; Athbah, 2024; Lan et al., 2024; Lemaignan et al., 2021). Personalization has been often mentioned, but its implementation has been quite different from one to another. The majority of the systems provided minimal capabilities, while only a few studies cited sophisticated methods like deep learning or real-time responsiveness for adaptive AI (Gu, 2023; Lyu et al., 2024; Priyadarshini et al., 2024; Lan et al., 2024; Lemaignan et al., 2021).

Integration difficulties were, by far, the most common obstacles mentioned, mainly due to the fact that AI technologies were not compatible with traditional treatment methods such as ABA, education settings, and even healthcare. On top of this, scalability was impacted by the lack of infrastructure, shortage of human resources, and limited deployment strategies (Gu, 2023; Athbah, 2024; Jiang et al., 2021; Sağdıç et al., 2024; Rêgo & Araújo-Filho, 2024). Although ethical and privacy concerns were very often just touched on, the discussion about data protection, informed consent, and the issues connected with embodied AI technologies had not gone that far. As a matter of fact, these concerns were most pronounced in the case of studies dealing with facial recognition and the collection of sensitive data (Lyu et al., 2024; El Shemy, 2022; Lemaignan et al., 2021; Sağdıç et al., 2024; Rêgo & Araújo-Filho, 2024). In sum, the results of this study emphasize the necessity of more stringent, diverse, and ethically grounded research as the key to unlocking the potential of AI in the area of autism education.

**Table 7:** Summary of recurring gaps in AI applications for autism education across six key dimensions.

| Dimension | Common Issues Across Studies | Representative Examples |
|---|---|---|
| **Empirical Evidence** | Small sample sizes, short-term trials, lack of longitudinal validation, weak clinical outcome data | Gu (2023), Jiang et al. (2021), El Shemy (2022), Athbah (2024), Lan et al. (2024) |
| **Personalisation & Adaptivity** | Shallow customization, limited adaptivity in robots, minimal multimodal integration, underdeveloped personalization strategies | Lyu et al. (2024), Priyadarshini et al. (2024), Lemaignan et al. (2021) |
| **Integration & Scalability** | Poor integration with ABA, limited deployment contexts, infrastructure/training gaps, weak generalizability, scalability concerns | Gu (2023), Jiang et al. (2021), Athbah (2024), Sağdıç et al. (2024), Rêgo & Araújo-Filho (2024) |
| **Ethical & Privacy Concerns** | Data privacy, consent issues, facial recognition risks, embodied AI concerns, vague ethical frameworks | Lyu et al. (2024), El Shemy (2022), Lemaignan et al. (2021), Sağdıç et al. (2024), Rêgo & Araújo-Filho (2024) |
| **Cultural & Contextual Gaps** | Lack of culturally sensitive insights, underrepresentation of autistic voices, limited regional diversity (esp. Arab/Asian contexts) | Jiang et al. (2021), Athbah (2024), Lemaignan et al. (2021) |
| **Design & Engagement** | Weak interaction design, poor engagement strategies, lack of empathy/social nuance, modality synchronization issues | Lyu et al. (2024), Sideraki & Drigas (2021), El Shemy (2022), Lan et al. (2024) |

Figure 6 shows a graphical summary of the limitations that were reported most often in the application of AI technology to autism education. Personalization and adaptivity (22.0%) and integration and scalability (22.0%) make up the largest parts, which indicate that there are already problems everywhere in their use to fit AI systems to learner profiles and in their use together with the existing therapeutic and educational infrastructures. Customization was a strong point for most systems, but at the same time, they had difficulty trying to fit into other practices like ABA, especially in less privileged contexts (Gu, 2023; Athbah, 2024; Jiang et al., 2021).

Empirical evidence (20.3%) also turned out to be a major concern. The generalizability of the studies and their clinical relevance were both affected by the fact that many of them relied on small sample sizes, and short-term trials, and lacked longitudinal outcome data (El Shemy, 2022; Lan et al., 2024). Promising outcomes such as better communication or engagement were reported by several interventions but these were often claimed as benefits rather than confirmed results, as standardized assessments or control groups were seldom used. This gap between reported potential and validated performance points to the necessity of more sophisticated study designs.

Ethical and privacy concerns (18.6%), though used as a common reference, were viewed in a shallow manner most of the time. The debates about biometric data, facial recognition, and obtaining proper consent are still hard to handle and are not quite developed in the area of user profiling that deals with very confidential data (Lyu et al., 2024; Rêgo & Araújo-Filho, 2024). Even though the writers stated that there were safety measures, only a few of the studies presented verified protocols or compliance evidence which left ethical assurances mostly unproven. Cultural and contextual gaps (8.5%) and design and engagement (8.5%) were the least mentioned, although being at the core of the issue of inclusivity and usability. Only a handful of studies have integrated culturally sensitive frameworks or have involved autistic people in the design process, especially in less represented areas like China and Arab countries (Jiang et al., 2021; Athbah, 2024). Further, poor user interface design, lack of interactive elements in the curriculum, and unresponsiveness from the behaviour went hand-in-hand with low educational impact (Lan et al., 2024; Stasolla et al., 2024). These drawbacks serve as a powerful indicator that the claimed usability and engagement did not often lead to the corresponding verification of educational outcomes.

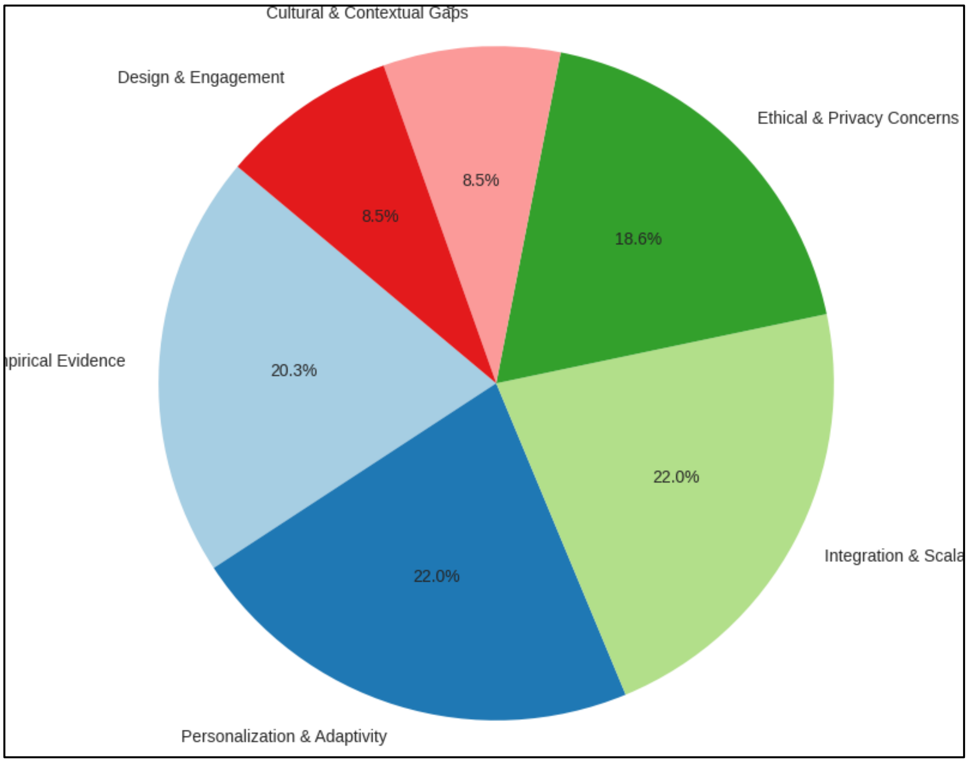


**Figure 6:** Distribution of Reported Gaps in AI Applications for Autism Education Across Six Key Dimensions

### *Cross-Dimensional Patterns and Synthesis*

Seeing the four dimensions from a broad perspective reveals quite a few recurring patterns. Among all these, the top three areas of attention—personalization, communication, and social-emotional learning—are predominantly powered by the applications of ML, NLP, SAR, and CV (Gu, 2023; Lyu et al., 2024; Jiang et al., 2021; Sideraki & Drigas, 2021). But still, the effects of these interventions are not very well verified due to their reliance on small samples, descriptive outcomes, and short-term trials. The places where techniques are used also affect the patterns: home and clinic environments highlight personalization and diagnostics, but outcomes are obscured by the involvement of caregivers and the inability to compare with clinical standards (Athbah, 2024; Vanaja & Raj, 2025). Research conducted in schools points out robots as tools for social interaction, but the robots are still in pilot phases, which prevents scaling up (Valentim et al., 2024; Lemaignan et al., 2021). The digital platforms offer new mediators like AR/VR, however, there is no proof of long-term learning improvements (El Shemy, 2022; Stasolla et al., 2024). The mentioned gaps always mirror these problems, since personalization, scalability, and empirical validation are often pointed out as the main hindrances, while the areas of ethical safeguards and cultural responsiveness remain the least developed (Habibi et al., 2025; Rêgo & Araújo-Filho, 2024; Dahan, 2021). Such an array of patterns also brings about the conflicting situation: the most promising areas—personalization, emotional responsiveness, and accessibility—are also the ones mostly affected by the drawbacks of research methodologies, the lack of large-scale implementations, and the absence of cultural sensitivity. Bringing down these intertwined barriers will not only be pivotal for the unlocking of AI's potential in the field of autism education but also for the provision of educational settings that are reliable, just, and contextually responsive.

### *Ethical and Cultural Considerations*

In addition to methodological drawbacks, the ethical and cultural aspects need to be considered more thoroughly in the assessment of AI applications in autism education. Ethical issues are mainly concerns in the case of the systems that operate on delicate biometric data like facial recognition, EEG signals, or speech recordings. Privacy, informed consent, and data protection are all issues that have not yet been developed very much and where most studies offer only shallow promises of compliance (Habibi et al., 2025). Furthermore, the importance of transparency and accountability cannot be overstated since a lot of interventions claim to have generated benefits without any standard validation. This situation casts doubt on the accuracy of the outcomes and raises concerns regarding the integrity of the reporting practices (Rêgo & Araújo-Filho, 2024). Cultural and contextual sensitivity is also a necessity, as shown in Dahan's (2021) Islamic model of autism that promotes dignity, compassion, and inclusivity.

Cultural aspects are also a largely neglected area in research. Very little attempts have been made to incorporate culturally attuned approaches or to customize interventions to different educational environments, though cultural and socioeconomic factors are largely responsible for learning preferences and, consequently, engagement (Habibi et al., 2025; Rêgo & Araújo-Filho, 2024). Moreover, the lack of participation from the autistic community in the designing and evaluating of AI systems restricts the inclusivity notion in places where their voice is already faint, like East Asia and the Middle East (EUCAP, 2025). The existence of such gaps warns of the dangers of continuing the same inequities if AI technologies are not carefully attending to cultural diversity and learner autonomy—calling for the use of faith-based and culturally grounded models like Dahan's (2021) Heart of Autism.

In order to facilitate a more precise evaluation, the present review introduces a five-dimensional model for the assessment of AI ethics in the context of ASD. Privacy and Data Protection—balancing the protection of sensitive learner data with the implementation of appropriate consent procedures that respect the culture (Habibi et al., 2025). Transparency and Validation—demanding proof based on a standardized approach plus context-specific reporting to back up the claimed effects (Rêgo & Araújo-Filho, 2024). Inclusivity and Cultural Responsiveness—bringing into play diverse cultural attitudes and beliefs, including Islamic values and autism spectrum voices, right from the design stage to the very end (EUCAP, 2025). Autonomy and Participation—enabling learner freedom of choice and participation of caretakers with the understanding of both individualistic and collectivistic cultural viewpoints (Lan et al., 2024). Spiritual and Ethical Grounding—relying on religiously-inspired models like Dahan's Heart of Autism that guarantee respect, kindness, and neighbourhood-based assistance (Dahan, 2021).

Dahan (2021) argues that autism, especially in the context of Islam, should be viewed as a spiritual experience, and thus, compassion, dignity, and spiritual purpose should be the primary considerations. Her Heart of Autism approach encourages the use of inclusive and non-stigmatizing methods that acknowledge the individuality of the autistic both in terms of their cognition and emotions. By incorporating such views into AI ethics, it guarantees that the interventions are not only effective from a technical point of view but also have a cultural impact and are socially fair.

Applying this combined framework underscores that while AI technologies hold promise for enhancing personalization, communication, and socio-emotional learning, their ethical robustness and cultural adaptability remain limited. Future research must therefore integrate these principles into both design and evaluation, ensuring that AI interventions are equitable, trustworthy, and contextually responsive.

### *Proposed Conceptual Framework for Future Research*

Building on the four descriptive dimensions, this review advances a conceptual framework for future research, as illustrated in Figure 7. The framework places AI modalities as instruments that solve particular educational areas, are used in different places, and are checked against the same methodological and practical gaps. The model is giving importance to the cultural and Islamic viewpoints, beaches of ethical safeguards, inclusiveness, and sensitivity to the context. The model is inspired by Dahan's Heart of Autism model (2021), which insists on compassion, dignity, and faith-based inclusion, and goes beyond the technical aspects to integrate the cultural and spiritual values in the evaluation of AI systems. Thus, the framework not only improves the methodological rigor but also guarantees that the AI technologies in autistic education are socially and culturally aware of the diverse requirements of the learners.

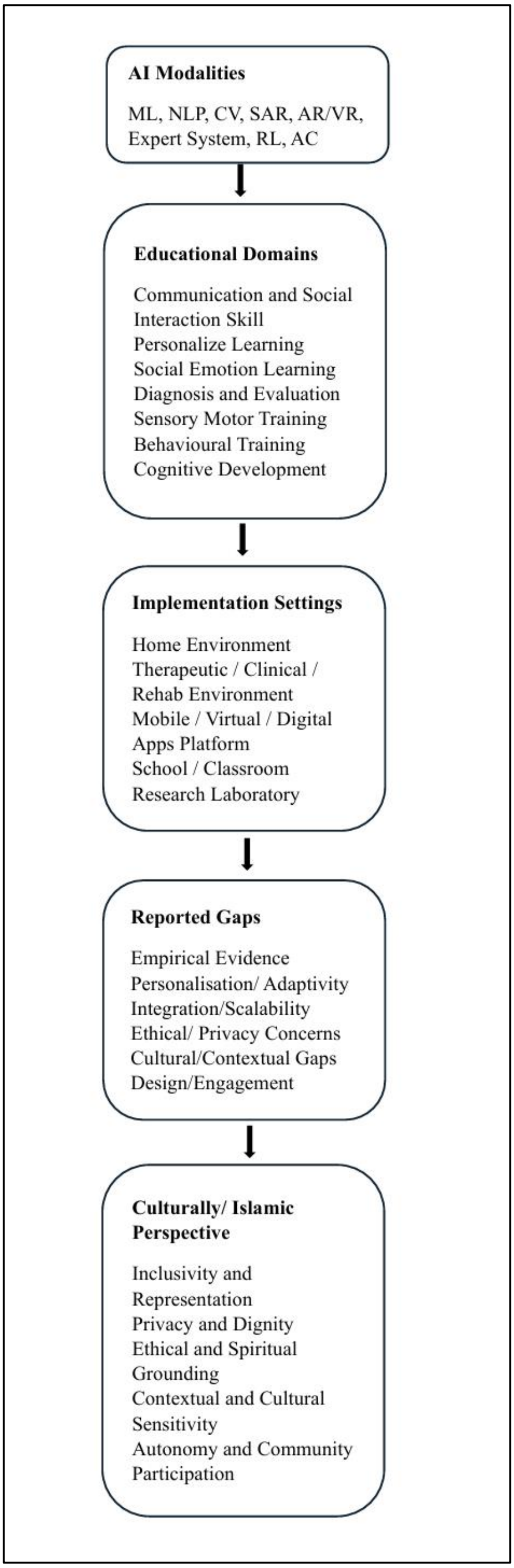


**Figure 7:** Proposed Conceptual Framework for AI in Autism Education

## Future Directions

The compilation of fifteen studies concludes that despite the fact that AI technologies have been advocacy for autism education, the unresolved challenges restrict their effectiveness and ampliative use of tech. Thus, the future research must focus on the longitudinal validation and scalable deployment as the current studies are mostly limited by small sample sizes, short-term feasibility tests, and insufficient validation. The following investigations are to be based on longitudinal designs, which will monitor the learning effects for different kinds of autism over time. Also, it is very important to create deployment strategies that are scalable, which means that the integration of these methods into educational, clinical, and home environments will be a smooth process. Personalization and Adaptive Responsiveness While personalization is the topic of discussion frequently, the functionality of most systems is still very limited. The next generation of AI systems should not only accept multimodal inputs—such as speech, facial expressions, and physiological signals—but also incorporate emotion-aware technologies to provide treatments tailored to individual sensory, behavioural, and cognitive needs. Real-time adaptivity and deep learning methodologies should be investigated in depth to maximize responsiveness. Ethical and Privacy Safeguards The issue of ethics in research, especially that of biometric data, facial recognition, and embodied AI, has not been given due consideration. Researchers in the future must not only create robust frameworks for transparency, but also for informed consent and respect for autonomy. These measures will be crucial to building trust and ensuring accountability in precious educational and therapeutic contexts.

Cultural and Contextual Relevance the lack of representation of cultural viewpoints, particularly in countries where Islam is the dominant religion, calls for more comprehensive research to be conducted. The studies that are to be done in the future should always include the co-design with autistic people, their caregivers, and teachers, and also the content should be localized to be sure of its sociocultural acceptability. It will be important to tackle the cultural barriers for the global relevance and fair acceptance of the technology. By systematically taking these priorities into consideration, the interventions powered by AI can move from being experimental prototypes to clinically validated, ethically sound, and culturally responsive systems. The role of AI in education for autism will be greatly increased in such a way that the impact on the ground will be practical and the sustainability will be long-term.

## Conclusion

The review brought together fifteen recently published studies on the incorporation of AI technologies in autism education and came up with a classification based on the four key features: AI modalities, educational domains, implementation environments, and gaps as reported. The findings point to a strong preference for NLP, ML, AC, SAR, and CV. The communication and social interaction skills were identified as the most frequently chosen educational domain, followed by personalized learning and SEL, while sensory-motor training still needs more research. Among the various implementations, home-based and therapeutic/clinical environments were the most common, which is consistent with the trend of a more personalized and accessible intervention through the use of digital platforms and schools pointing towards hybrid, technology-mediated approaches. The review, however, raised several challenges that need to be solved before the widespread use of AI in autism education. Gaps in empirical validation were pronounced across the studies, with a majority of them relying on small-sized, short-durations, and lack of longitudinal outcome data. Personalization and adaptivity were mentioned a lot but hardly ever implemented, while integration into existing treatment paradigms, educational systems, and healthcare infrastructures remains very limited. Ethical and privacy issues, especially those related to biometric data, facial recognition, and embodied AI, were often insufficiently addressed, and cultural and contextual gaps are still there, as few studies have incorporated neurodiversity-affirming principles or culturally sensitive insights.

Longitudinal validation and large-scale deployment, which will be necessary for the sustainability of outcomes across different autism profiles, must therefore be the first point of research attention. Likewise, the creation of such AI systems whose operation is dictated by the different individual sensory, behavioural, and cognitive needs is paramount. These technologies will be utilizing multimodal and emotion-aware abilities. On the topic of ethical frameworks, it is the case that robust ones dealing with transparency, informed consent, and autonomy are a must, especially when dealing with sensitive data. Lastly, the issue of cultural and contextual relevance must be given a much larger share of the pie, and thus, the research in less represented areas and the co-design with autistic people and their caretakers must be highlighted to ensure inclusiveness and sociocultural acceptability. Clearing these hurdles will enable the AI-powered interventions to grow from being mere experimental prototypes to clinically validated, ethically grounded, and culturally responsive systems, thus giving a big boost to the autism education field in terms of both its breadth and sustainability.

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