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An Examination of Ai-Powered Remedies for Students with Autism Spectrum Disorder

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Abstract
"Autism Spectrum Disorder (ASD)" is a complex disorder of development characterized by difficulties, limited interests, and repetitive activities in building and maintaining mutual social relationships. Technology is often viewed by individuals with ASD as approachable and less socially intrusive. The application of artificial intelligence (AI) in educational settings has garnered increasing attention in recent years. A comprehensive review of studies published between 2018 and 2024—focused on children with ASD who often struggle in areas such as academics, cognition, and social interaction—yielded 1,762 articles across three major online databases. After applying specific inclusion criteria, 13 empirical studies were chosen for detailed coding and evaluation. These studies demonstrated both the potential benefits of AI in supporting the learning needs of children with ASD and highlighted several gaps in current research. The article ends by emphasizing the importance of future investigations, particularly in evaluating the long-term impact and developing standardized frameworks for AI-based educational applications targeting ASD learners.

Keywords: Autism Spectrum Disorder (ASD), Education, Intervention, And Artificial Intelligence (AI)

1. Introduction

To support educational processes, assistive technology—which includes a broad range of tools, systems, and services that make it easier to utilize assistive devices and enhance service delivery—has seen significant development. It plays a crucial role in ensuring inclusive participation and fostering academic achievement for students in diverse learning settings [1]. John McCarthy introduced the term "artificial intelligence" (AI) in 1956. [2] says that AI is the ability of computers to use digital technologies, algorithmic systems, machine learning, and other methods that are typically associated with human intelligence to perform tasks like learning and reasoning. The replication and boosting of human activities using AI are useful to enhance efficiency, stimulate the growth of new ideas, and address difficult problems in various disciplines, such as education—and especially in tasks where analysis, synthesis, adaptation, and learning are competent [3–5]. As its educational implications become more popular, there is a trend to explore AI with its potential to liberate learning, aid in assessment, improve education by adding to the experience, and provide instructional guidance [6]. The research outlines the potential of AI to empower all learners as they learn important skills in a personalized and engaging manner. Particularly, the AI-powered tools can provide individual guidance and support corresponding to each learner's unique profile, tastes, and interests [7]. These technologies may also relieve teachers of work burdens by automating trials of knowledge. Furthermore, algorithm-based systems are usually incorporated in educational spaces under different digital packages, including mobile apps and social networks. Robotic systems, intelligent tutoring systems, and adaptive learning platforms illustrate AI's capacity to provide individualized assistance to specific learning activities [5].

1.1. Literature Review

Recently, there was a rise in adopting artificial intelligence (AI) in special education environments [4, 8]. AI technologies are especially good at providing customized learning opportunities that target the specific needs and learning profiles of all learners [8]. In accordance with universal design principles, AI facilitates various ways of instruction and customized educational material [9, 10, 11]. AI-driven tools and other virtual and augmented reality-based tools provide a more immersive and engaging environment for three-dimensional learning for students that need special education (Vincent Lancrin and Van der Vlies) [12]. Such tools can help students make the abstruse or invisible concepts clear much better [13], thus enhancing academic performance as students are exposed to lifelike real world situations. As emphasized by recent research [14], the effectiveness of the application of AI mostly depends on purpose. The most common applications include personalizing instruction and simplifying the learning process of the students with unique educational struggles.

AI-based interventions are increasingly expected to offer meaningful support for children diagnosed with autism spectrum disorder (ASD). Digital technologies appear to enhance educational outcomes and cater to the unique needs of individuals with

ASD [15]. AI has the capacity to adapt to the distinct characteristics and specific requirements of these children. As expressed by "fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders (DSM-5)"*, ASD is a neurodevelopmental condition marked by repetitive and stereotypical behaviors, along with significant challenges in social communication and interaction [16]. Individuals with ASD often vary in their developmental abilities across academic, social, and daily functioning domains, and they may experience difficulty recognizing social signals, understanding emotions, and navigating social situations [17,18]. AI technologies support innovative educational strategies and hold promise in crafting personalized, inclusive learning environments for all students. Despite this potential, current research on the use of AI-based interventions to assist educators and learners with ASD remains limited.

1.2. The Present Study

Reviewing AI's impact on teaching and learning for kids with ASD was the aim of the present research. The influence of AI extends to the intellectual, social, and linguistic content of special education, as well as to the practical and emotional spheres. The following questions were taken into account:

RQ1: Which AI-based therapies for kids with ASD are done being researched upon?

RQ2: What learning aims are met?

RQ3: Why is AI beneficial in educational setup?

Teachers, special educators, and other professionals working with kids who have ASD may find value in the research's conclusions.

1.3 Objectives of the research

1. To explore the types and functionalities of AI-based interventions used to support students with autism spectrum disorder (ASD).
2. To assess the educational domains and learning outcomes targeted by AI-enabled interventions for children with ASD.
3. To evaluate the pedagogical benefits and ethical considerations of integrating AI in educational settings for ASD learners.

2. Methodology

The purpose of this study was to locate significant studies for applying AI in ASD children's education and form a conclusion. Due to the requirement to monitor recent study data due to the rapid growth of technology, we only examined 13 studies from 2018 to 2024; none from prior to 2018 were included. The paper uses descriptive approaches.

2.1. Selection of Studies and Eligibility Criteria

Indices for a literature collection of Related articles were generated from the three academic data bases: Scopus, Specifically, Science direct and ERIC, from the Boolean formulation of keywords that originated from the study's Area of interest AI and machine learning and deep learning ("Artificial Intelligence" OR "Machine Learning" OR "Deep Learning"), education and ASD ("teaching" OR "Or learning" OR "Intervention" OR "Instruction"). This initial search yielded 1,746 results. Thus, adding 16 more over the id added by crawlers and having a total of 1,762 entries. Based on the inclusion criteria, the selection of the articles for this review was achieved: (1) the article focused on the use of AI in educational settings; (2) the participants of the study were students with ASD in the primary, secondary, or postsecondary level; (3) the articles were published after 2018; and (4) the study was quantitative or mixed-methods research, published in peer-reviewed academic journals or presented at the conference.

Mendeley Desktop (v1.19.5) was used to manage citations and eliminate duplicate records. Additional relevant studies were identified through reference mining. Two researchers screened the titles and abstracts of 121 papers based on the inclusion criteria. Three reviewers then retrieved and examined the full texts of the shortlisted articles. After the screening process, 13 studies met all the criteria and were included in the final review. Studies excluded at the full-text stage generally lacked empirical evidence or focused solely on theoretical frameworks or assessment tools. Ultimately, the authors agreed upon the inclusion of these 13 studies following a thorough and systematic review process.

2.2. Data Analysis

Data obtained from the selected studies were categorized into three sections namely, Source Information, Substantive Contents, and Methodology/Procedure. Data extraction and coding were done using Microsoft Excel. Additional information was highlighted in the source description, including the research's place of origin, journal, author group, and publication date. The types of intervention implementer, the context in which the intervention was carried out, age, and facets of the participants, uses of AI were all considered as posing substantive issues. The sort of study approach, the goals of the intervention, and the results were all covered in the research methodologies and procedures. The two writers of this paper separately coded the research based on their attributes and categorized them using the established categories and subcategories. To get to a consensus, the third and fourth writers reexamine this data. Discussion was used to settle any disagreements between the developers.

The preceding table presents and summarizes the data's analysis and coding which also offers an overview of the primary results and salient features (Table 1).

Table 1 Synthesis of the research that has been evaluated.

Citation	Participants (ASD)/Age	Setting/Instructors	Technology and AI	Intervention Practices / Content / Research Design	Learning Outcomes
Chung [19]	n = 14 (M) / 9–11	School / Researchers	SR and AI	SI—Robotic game-based; Social skills—Social interaction—SD; GS—Quan.	Positive (motivation and engagement, eye contact frequency and duration, verbal initiation)
Daniels et al. [20]	n = 23 (19 M, 4 F) / Mean age 11.65	Not specified / Researchers	SG and AI	EI; Emotions—Emotion recognition—ED; GS—Quan.	Positive (comfort while wearing glasses, emotion labeling accuracy, confusion between emotions)
Daniels et al. [21]	n = 14 (11 M, 3 F) / Mean age 9.57	Home / Parents	SG and AI	IT—Game-based intervention; Social skills—Social interaction—SD; GS—Quan. and Qual.	Positive (eye contact and social acuity)
Kalantarian et al. [22]	n = 8 / 4–12	Home / Researchers—Parents	Android app	IT—Game-based intervention; Emotions—Face tracking—Emotion recognition—CD and ED; GS—Quan.	Positive (real-time assessment, engagement, emotional state)
Sahin et al. [23]	n = 1 (M) / Mean age 13.11	School / Parents—Teachers	SG and AI	SI—AR-assisted and game-based; Social communication, cognition, motivation—SD; CS and SSS—Quan.	Positive (social communication)
Scassellati et al. [24]	n = 12 (7 M, 5 F) / 6–12	Home / Parents—Caregivers	SR and AI	Home-based and robotic game-based; Social communication—SD; Group	Positive (social communication, motivation, social cognition,

				treatment—Quan.	reduction in restricted interests and repetitive behaviors)
Vahabzadeh et al. [25]	n = 4 (M) / Mean age 7.5	School / Teachers	SG and AI	SI; Social communication—SD; SSS—Quan.	Positive (reduction in irritability, hyperactivity, and social withdrawal)
Zhang et al. [26]	n = 20 (18 M, 2 F) / 5–9	School / Researchers	SR and AI	SI; Complex social rules—SD; GS—Quan.	Positive
Baldassarri et al. [27]	n = 12 (8 M, 4 F) / 10–18	Special education center / Researchers—Teachers—Parents	VG—Tangible tabletops and AI	SI and IT; Emotional recognition, attention, and engagement—ED and CD; GS—Quan. and Qual.	Positive (increased interest, motivation, attention, accurate emotion labeling)
Moon et al. [28]	n = 4 (M) / 13–19	Not specified / Researchers, postgraduate students	VR and AI	IB—Problem solving; STEM / Automatic assessment cognitive and emotional—CD; RCT—Quan.	Positive (cognitive and emotional flexibility)
Wan et al. [29]	n = 10 / 5–10	Hospital / Researchers	Human-computer-robot interaction system and AI	SI; Emotions—Recognize and express emotions—ED; Not clear—Quan.	Positive (effective recognition and expression of basic emotions, increased interest)
Tuna [30]	n = 2 (1 M, 1 F) / 6–8	School / Teachers	SR and AI	Least to most prompting—Robotic game-based; Emotional development and communication—SD; SSS—Quan.	Positive (improved symbolic play skills)
Li et al. [31]	n = 18 (14 M, 4 F) / 5–8	Local rehabilitation center / Researchers—	AR and AI	SI—Game-based instruction; Facial expression recognition and social	Positive (increased engagement, attention, participation,

		Parents—Teachers		communication—SD; GS—Quan.	improved facial expression recognition)

3. Results and Discussion

Results have been arranged according to traits, environment and public involved, as well as the research issues that the empirical studies that are part of this review address.

3.1. Study Characteristics

Based on the review's criteria, the search for papers included the years 2018 through 2024. According to the publications' yearly distribution, the majority of the studies (seven) were released in 2018, followed by one in 2019, two in 2020, two in 2022, and one in 2023 (refer to Table 1). The bulk of the research were published in information technology-related publications [20,24,26,29-31], and They appeared in reputable scientific journals from fields like education [23] and health sciences [19,21,22]. Four different countries were the sites of these investigations: Spain [27], China [19,26,29,31], the United States of America [20–25,28], and Turkey [30].

3.2. Participants and Settings

192 people participated in the research overall, with 1–43 people taking part in each trial. Participants ranged in age from four to nineteen. Of the 192 individuals in the sample, a number of 148 are found to be diagnosed with ASD and 44 were designated as normally evolving and played as "control groups". It has been reported that the people were Caucasian, Asian, Hawaiian, Chinese, or Hispanic [20,23,24,26]. Even though, information on the participants' ethnicity was absent from the majority of research. Regarding the participants' gender, the vast majority of the research revealed that they were men. The majority of the studies included details on the site of the interventions' implementation. However, via participant and teacher interaction, several research indirectly revealed this information. To be more precise, the majority of the interventions were carried out in educational environments, including schools or special education centers [19,23,25,26,30]. The remaining interventions were carried out in a variety of locations, including hospitals [29], schools [23,25,26,30], or homes [21,22,24]. Parents, teachers, caregivers, the school pedagogical team, and the researchers of the corresponding studies were the instructors who carried out each intervention (see Table 1). Researchers worked with parents or instructors in a number of studies [21-25,27,30,31].

3.3. RQ1: Which AI-based therapies for kids with ASD are done being researched upon?

3.3.1. AI Technology

Given that technology can enhance the educational process and promote the best possible development for kids with ASD, this might be the case [32]. It was discovered that the study's methodology was predicated on applying the digital technologies that were made available. Curiously, the two also demonstrated that the primary application of the technology was to gather, handle, and evaluate video data, frequently using electronic devices like cameras to record individuals.

Four instructional treatments based on social robots are also identified by the research [19,24,26,30]. For example, Chung [19] used a humanoid robot to help teachers lead planned social activities like storytelling, dancing, and singing. One computer with touch screen, one robot and two of cameras that too RGB make up the robot assisted system utilized by Scassellati et al. [24] to monitor and record student interactions with caretakers. As demonstrated by "Zhang et al. [26]", NAO- arobot that is a humanoid was used for teaching pupils complicated conventions-connections via interactive gaming activities. In addition to [30], Tuna, another roboticist, using a humanoid robot to improve the symbolic engagement of children with ASD in play and education. Additionally, five other research used digital apps on cellphones, tablets, and PCs [22,27,29,31]. Baldassarri et al. [27] employed mobile-based serious games to help students with ASD pay better attention and communicate more effectively. The Guess What app for Android was utilized by Kalantarian et al. [22] to track and measure the affective and behavioral states of students while encouraging them to mimic facial expressions and develop their imagination. The "FaceMe augmented reality" game was utilized by Li et al. [31] to enhance social emotional learning by teaching the identification of fundamental facial emotions in social situations. Using voice data and natural language processing, Moon et al. [28] demonstrated an automated approach for evaluating the cognitive and emotional states of children with ASD. "The Facial Emotion Cognition and Training System (FECTS)", a human-computer interaction tool designed to educate kids with ASD how to identify emotions, was also studied by Wan et al. [29].

Lastly, smart glasses with AI capabilities were used in all four of the augmented reality-based research. Therapies to identify emotions using a computer interface or an Android app on "Google Glass Explorer Edition" improved eye-contact and provided visuals in real time and gave auditory form of feedback when the eyes are not in contact with the instructor were studied (Daniels et al. [20], [21], Sahin et al. [23], and Vahabzadeh et al. [25]).

3.3.2. Practices of Intervention

Games served as foundation for majority interventions [19,21,22,23,24,30,31]. There are several benefits of using game-based therapies [33]. Serious games, for instance, have been shown to improve emotion awareness in kids with neurodevelopmental issues and lower stress and anxiety levels [34]. As seen by our review, children with ASD, who often benefit from routine and consistency, benefited greatly from the gaming environment's use of explicit rules, repetition, and instant feedback. Additionally, a number of research used digital games with visual and interactive components to successfully grab the interest of adolescents with ASD [33, 34].

Regarding instructional strategies, most of the research employed systematic instruction, which comprises structured, sequential training [19,25,26,27,29]. Theories specifically employed training in a system for skills teaching for example, the ability to perceive and express emotions in a regulated and repetitive way, making sure that each skill was learned before going on to the next. The researchers supported previous research [31] on the benefits of systematic instruction as a teaching strategy for children with ASD by using augmented reality or robot-assisted techniques to give clear and consistent instructions. Furthermore, our analysis revealed that researchers have incorporated interactive training into their approaches [21,22,27], providing engaging and dynamic learning opportunities through the use of robotics or augmented reality. It was demonstrated that students exhibited unique learning scenario patterns in identical-design problem-solving tasks related to inquiry learning, emphasizing the need for efficient, AI-powered, automated evaluation [28]. Students could benefit from tailored education that supports their social and intellectual growth in this way. Additionally, a study helped children with ASD participate in symbolic play [30] by using prompting, a teaching approach that is effective in special education [32, 35].

In order to create appropriate learning environments that emphasize social, emotional, and cognitive content, the evaluated research show a wide variety of teaching strategies and methodologies that integrate different forms of artificial intelligence. The learning activities were thoughtfully created to address the distinct requirements and characteristics of kids with ASD.

3.4 RQ2: What learning aims are met?

3.4.1. Content

Collectively, the main focus of the research was on the social communication, emotional awareness, and social skills of students with ASD. With the aim of meeting its objectives, which involved enhancing the ability of children with ASD to identify and communicate emotions, to understand social cues, and to engage in social interactions, the research used many digital technologies.

Five scholarly works [20, 22, 27, 29, 31] explored the teaching of children with ASD how to identify and interpret facial expressions, an essential ability in understanding emotions. The topics of emotions discussed included happiness, sadness, wrath, fear, disgust, surprise, neutrality, and even disdain. To assist students with greater fluency of social interaction and emotional detection, various kinds of emotions were taught, ranging from basic to complex. One of the primary objectives of these studies was to enhance the social skills of adolescents with ASD, including eye contact, social drive, and social cognition [19, 21, 24, 25, 26, 30, 31]. Eye contact strategies were also often mentioned due to the importance of eye contact during social interaction and nonverbal communication [19,21]. Also, as mentioned by some research, the benefit of social norms and perspective taking to children with ASD should be taught because these skills are crucial for understanding social dynamics and nurturing empathy [21,26].

Two more studies examined social skills, cognitive processes, and behavioral regulation [22, 27]. For instance, by requiring students to exercise emotional and behavioral control, the "Emotional Trainer" [27] and VR-based games may improve cognitive planning, attention, and memory. In terms of their overall growth and adaptive functioning, students with ASD gain from better learning results. One of the examined studies only addressed STEM (science, technology, engineering, and mathematics)-related themes, despite its primary focus on social and emotional development [28]. This suggests that the current corpus of research has focused more on examples that foster social and emotional development than on intellectual fields like STEM.

3.4.2. Domain of Education

The first study concerned the cognitive development of children, second explored the emotional domain, third two also the social domain, while the remainder two touched the emotional and cognitive aspects. Social robots have been used in therapeutic interventions to improve adolescents with Autism Spectrum Disorder (ASD)'s social skills, according to several previous studies [19,24,26,28]. These robots were primarily used to facilitate social connection, initiate verbal communication, foster eye contact, encourage symbolic play, and teach social standards.

However, other researchers developed smart glasses to improve children with ASD's social competencies [21,23,25]. Targeted training of children was carried out to help them identify the use of facial expressions and to make eye contact in social interactions. In fact, Li et al. study [31] utilized augmented reality and AI technologies to help students understand facial emotions, as well as their social communication skills.

Four studies of emotion-centered interventions focused either on teaching individuals with ASD how to recognize and express their feelings or measuring their emotional responses in training sessions. For these efforts, different digital tools were used, including personal computers [29], video games, smart glasses [20,21], an interactive touch table [27] and an AI powered Android application [20].

In the last, three [22, 27, 28] studies were aimed at the enhancement of cognitive abilities in adolescents with ASD.

3.4.3. Design of Experiments in Research

An examination of the approaches used in the literature found that, in order to achieve the stated goals, quantitative approaches were most often used, with only a small number of research using "qualitative analyses" [21,27].

Studies examining the effectiveness of AI-based therapy for adolescents with ASD have included a variety of experimental and research approaches. Some investigations, such as those by Daniels et al. [20,21], Kalantarian et al. [22], and Scassellati et al. [24], used group studies without control groups. However, some studies, including those by Zhang et al. [26], Baldassarri et al. [27], and Li et al. [31], employed group research, with control groups consisting of children with ASD and children with normal development. This variation in study design illustrates the variety of approaches being used by researchers to understand and evaluate AI therapy for ASD.

When therapies are tailored to the needs of particular people or when the number of participants is restricted, the single-subject research design employed in Tuna's [30] study is particularly usefulIn their case study of a 13-year-old participant, Sahin et al. [23] used similar elements of a single-subject experimental design, concentrating on the impact of the intervention on a single person.

While Wan et al. [29] did not identify the study design they used, Vahabzadeh et al. [25] integrated a number of components to optimize the advantages of numerous research approaches.

3.5. RQ3: Why is AI beneficial in educational setup?

3.5.1. Results

As summarized in Table 1, all the included studies described the positive effects of the implementation. For instance, in Chung's study [19], it was found that when the students interacted with a humanoid robot their motivation and engagement improved further, the frequency of eye contact and utterances raised and the time students spent initiating talk with peers with ASD also increased. Daniels et al. [20] discussed the way of recognizing faces with the help of Google Glass wearable technology. It was found that after using the device, children did not find it uncomfortable and it was not very stimulating for them and it revealed a statistically significant improvement on the recognition task for the Facial Emotion Recognition Test.

Social connection among students using an Android emotion recognition app and Superpower Glass smart glasses. Similarly, their eye contact, as well as social awareness,…I noticed some improvement during the time I saw them using the Android emotion detection and Superpower Glass smart glasses. In another study [21] it was as well noted that parents and caregivers noted improvement in children's performance in recognizing gestures and facial expressions, eye-to-eye contact, and social behavior. Such information was gathered using the guess what Android application employed by Kalantarian et al. [22] during their study to evaluate the students'' emotional intensity and their level of engagement throughout the learning process with the students with ASD. It cleared showed that the used app was an efficient tool that used game-based data collection.

According to Sahin et al. [23], there are positive changes regarding social communication, interactions, cognition, motivation, and interests after the applying the Empowered Brain Face2Face educational system. Vahabzadeh et al. [25] found out that there was improvement in social withdrawal, irritability, hyperactivity and stereotypical behaviors. Similarly, the study conducted by Scassellati et al. [24] neutralized a significant increase in social communication, social motivation as well as social cognition, though reduction of repetitive behavior and restricted interests.

Furthermore, it was shown that even without the robot, pupils' attention spans improved. Students with ASD were shown to have difficulty acquiring the intricate social norms that the robot taught in the Zhang et al. research [26]. However, a successful strategy for promoting social learning was the deployment of social robots.

Sustained attention and a noticeable interest in and drive for play activities were observed by the kids with ASD according to Baldassarri et al. [27]. They proved that they can execute the required duties very quickly and efficiently. They found it more difficult but succeeded in re-creating emotions such as disgust, melanchody, and neutrality in their ability to imitate emotions—like happiness, fear, anger, and surprise—was a key focus of the study. Further development of assessment system provided by Moon et al. [26] was found helpful for students with ASD making us able to help their virtual reality (VR) training by using automated evaluations of both emotional and cognitive state. The training program is based on a model of interaction: human–computer–robot including recognition and expression of basic emotion fear, anger, sadness, and joy. Students were able to easily use the software and showed improvements on their ability at mimicking and expressing emotions. In addition, they tended to be more engaged with this interactive system compared to other forms of teaching [29].

During all sessions of Tuna's pilot study [30], students were very engaged with the robot. In addition, they made great progress in their symbolic play skills. Playing the social AR game FaceMe promoted active involvement, attention and engagement in students with ASD and compared with controls. It was found that the participants thought that the experience of the game was great as well as having an increase in the recognition of facial expression [31].

Objective 1:

To explore the types and functionalities of AI-based interventions used to support students with Autism Spectrum Disorder (ASD).

Discussion:
This goal focuses on ascertaining the range and exact abilities of AI tools used in educational interventions for the AS disabled students. The studied works show a vast scope of AI-powered solutions such as social robots, smart glasses, mobile applications, and augmented reality systems. Social robots such as NAO and other humanoid devices enhanced student interaction and engagement in structured learning, symbolic play, and emotion recognition. Besides, wearable technologies like Google Glass-enabled "Empowered Brain" provided real-time feedback about facial expressions and eye contact, helping to develop social and emotional competencies. Emotional recognition and imagination training was assisted by AI-enabled mobile apps such as "Guess What" and "FaceMe", with the help of an interactive game mechanism. These tools represent the changing nature of the way AI should be able to retrieve, arrange, and use user behavior to enable what is appropriate based on student needs with ASD by customizing educational practices.

Objective 2:

To assess the educational domains and learning outcomes targeted by AI-enabled interventions for children with ASD.

Discussion:
The educational interventions examined in the study primarily targeted three key domains: emotional, social, and cognitive development. Most AI-based solutions aimed to enhance emotional awareness, such as the ability to identify, express, and understand facial expressions and affective states. Social skills development—including improving eye contact, turn-taking, social norms, and perspective-taking—was another major focus. Several tools, including augmented reality games and intelligent tutoring systems, also contributed to cognitive functions such as attention, memory, and executive functioning. However, the findings also revealed that relatively fewer studies focused on traditional academic domains such as STEM. The predominant emphasis on social-emotional learning reflects the core challenges faced by children with ASD and highlights the relevance of AI in facilitating behavioral and interpersonal growth that traditional classroom settings might struggle to address effectively.

Objective 3:

To evaluate the pedagogical benefits and ethical considerations of integrating AI in educational settings for ASD learners.

Discussion:
The pedagogical value of AI in special education lies in its ability to offer individualized, responsive, and engaging learning experiences. The reviewed studies consistently reported improvements in student engagement, emotional recognition, social interaction, and behavior regulation following AI-based interventions. Real-time feedback, interactive content, and the capacity for adaptive learning paths allowed educators to personalize instruction and monitor progress more efficiently. However, the integration of AI also raises significant ethical issues. Concerns regarding data privacy, algorithmic transparency, informed consent, and cultural sensitivity must be addressed, particularly given the vulnerability of the population involved. The document emphasizes that without robust safeguards and ethical frameworks, the risk of misuse, bias, or over-reliance on AI could undermine the benefits. Therefore, while AI presents transformative potential in special education, its implementation must be accompanied by responsible governance and inclusive design practices that prioritize student well-being and dignity.

3.5.2. AI's Contribution

Three categories of digital tools—social robots, digital gadgets including computers, tablets, and smartphones, and smart glasses—were recognized for use in teaching kids with ASD. The usage of diverse robot types with varying capacities and functions constitutes a rapidly evolving area with applications. With encouraging outcomes in the intellectual, social, emotional, and communicative abilities that the learning activities aim to develop, AI-enabled robots are being used more and more in the education of kids with ASD [19,24,26,30]. Positive outcomes were seen for children with ASD in studies that sought to improve their ability to recognize emotions, remember things, and pay attention using instructional video games [27] and digital apps on portable devices including computers, tablets, and smartphones [22,28,29,31]. Additionally, the use of AI-powered smart glasses, which emphasize eye contact and emotion identification, represented a novel strategy to enhance the attention of children with ASD [20,21,23,25].

Specifically, research on school-aged students with ASD and early intervention or pre-school learning environments may provide essential education for students [11,12] and improve social relations, which is a problem that learners with ASD face due to impaired communication and interaction skills [15,19,21,23,24,25,26,30,31]. Furthermore, the self-awareness of other increased, which involved the emotional and mental state of people as a result of AI-based treatments [20,22,27,29]. In the final analysis, it is obvious that AI has positively contributed to the field of cognition through providing opportunities to monitor and assess the processes involved in training [22,027,28]. When these treatments are widely adopted to be implemented in home and school environments, the applicability of these treatments are highly beneficial when it involves the parents and teachers.

Our analysis shows that, especially for kids with ASD, the AI usage for special education in a revolutionary age. The ability of AI tools to support social interaction, cognitive growth, and individualized learning in inclusive, safe, and regulated learning settings for children with ASD is what gives them pedagogical value. By adjusting to each student's particular strengths, challenges, and problems, AI technologies provide individualized educational experiences with favorable learning results [19,20,21,23,24,25,26,27,29,30,31]. Furthermore, AI-driven tools like digital platforms and social robots help students with ASD learn critical skills of communicating [19,24,26,30,31], which they often struggle with. Additionally, these technologies provide real-time feedback and ongoing evaluation [22,28], which enables educators (teachers and caregivers) to modify their teaching methods in real-time to fulfill the educational requirements of kids with ASD. Furthermore, AI is essential for improving communication, particularly for children who are non-verbal or have speech impairments [19,20,21,22,23,24,25,26,27,28,29,30]. These tools also play a key role in tracking and evaluating social, emotional, and behavioral elements, offering insights into patterns and triggers that may guide more successful treatments [22, 28]. Additionally, social settings may be simulated by AI-powered apps and robots, providing students with ASD with essential interaction practice [19,24,26,29,30].

Despite the rapid advancement of artificial intelligence (AI) in education, its proper and equitable application requires careful consideration of potential risks and moral dilemmas [35, 36]. Among the primary concerns are commercialization, an excessive dependence on artificial intelligence, algorithmic bias and discrimination, unequal access, privacy and data security, informed consent for data usage, ethical data management, and diminished autonomy for educators and learners [36].

AI may enhance the educational experiences of children with ASD if it is applied carefully and appropriately, as it was developed to assist people. However, when AI is used to assist individuals with ASD in managing their emotions, these privacy and ethical concerns become much more urgent. For autistic people and their caregivers to give their informed consent, the procedure and dangers of the AI intervention must be thoroughly explained. Strong data security protocols are required, and people must practice self-control, to prevent unwanted access to private medical data [35, 36].

Algorithmic transparency is another crucial factor. By enabling individuals to understand how AI systems function, it fosters a sense of control and respect for people's cognitive abilities. Cultural awareness is also necessary to ensure that interventions respect the customs and beliefs of different groups and avoid harm in different cultural situations. Because users must have the freedom to decide whether or not to engage with AI-driven emotional management systems, autonomy is essential. Maintaining the openness of AI algorithms helps avoid biased or incorrect responses, and ongoing advancements result in more efficient and fair support for people with autism. Concerns about ethics and privacy are interwoven, emphasizing the value of robust data security, transparent communication, and constant consideration of cultural diversity.
In conclusion, customized learning systems give students prompt, comprehensive feedback that significantly enhances their writing skills, while automated assessment technologies free up instructors' time so they may focus more on the needs of each individual student. The future of education and how to make it more effective and inclusive for all kids will be greatly influenced by the collaboration of AI and educators. The teacher's involvement is still crucial, though, because fostering a supportive and engaging learning environment calls for their guidance, empathy, and adaptability in order to fulfill each student's unique needs [36,37,38].

4. Limitations

A number of limitations in this study underscore the need for more investigation. Only thirteen studies were found to meet the inclusion criteria, which is the primary restriction. Furthermore, just three databases—ERIC, Scopus, and Science Direct—were searched, which would have excluded articles included in other databases including ProQuest, Web of Science, and Google Scholar. Despite concentrating on the most current research over the last seven years, the publication year range may have left out a significant portion of pertinent studies. Furthermore, the majority of the evaluated findings were from Asia and the United States. The "article" document type was used for this evaluation. Future scholars may want to look at theses, dissertations, reviews, and editorials. The absence of research on the preservation and generalization of abilities learned by students with ASD is another drawback associated with the coding process. Lastly, the inclusion of additional impairments might help to alleviate the constraint that the selection of ASD may have presented to this study. Because of these limitations and the fact that this topic is still in its infancy, there are several clear avenues for further research.

5. Conclusions

The main conclusions from the social, cognitive, and academic facets of AI's potential to help students with ASD were compiled in this review. Since AI research for children with ASD is still in its infancy, the findings support more scientific investigation and highlight the need of professional cooperation in creating evidence-based approaches [20,21,23,25]. Geographical disparities, especially in Europe, studies conducted before 2018, and societal and economic constraints that can restrict kids with impairments and their families' access to AI technology all need further investigation. Notably, several writers have contributed to many studies, indicating cross-disciplinary cooperation or consistency in the study methodology The majority of individuals were men, which is consistent with the usual male to female prevalence ratio of ASD [39]. These findings are in line with Rice and Dunn's [40] focus on the vital roles that parents, teachers, and other caregivers play in supporting kids with ASD. Finding the general characteristics of the included therapies was the goal of the first research question. In this sense, social robots, smart glasses, and computer, smartphone, and tablet apps are the digital instruments used in the examined interventions that surfaced. The majority of the examined studies reported employing game-based treatments to accomplish the educational objectives. Additionally, a large number of them used digital prompts throughout the teaching process. Lastly, it was shown that although some research focused on instructional constructivist tactics primarily based on simulations, others used basic strategies based on information consumption. Examining the instructional goals of the examined studies was the focus of the second research question. In this sense, it was discovered that the majority of the time, the educational goals focused on emotional and social development. The cognitive processes and learning efficacy were only analyzed in a small number of instances. Lastly, the final research topic was to identify the primary learning outcomes that AI studies assess. In that regard, it was discovered that the research' trials mostly assessed emotional and cognitive results. According to the data from the research done so far, these treatments are successful in promoting favorable learning outcomes in domains like the social and emotional ones that are especially significant for children with ASD.

In summary, every intervention that was examined had favorable results, demonstrating AI's potential for teaching kids with ASD [38]. Further study is required to better understand the educational journeys of pupils with ASD undergoing evidence-based AI therapies, even if these studies provide insightful information on AI technology in educational settings. To properly examine AI's involvement in inclusive learning, future research should include quantitative and qualitative indicators. The development of AI technology holds promise for improved educational opportunities and increased inclusion of students with impairments. In addition to examining student interactions in AI-driven settings, future studies should expand to include additional impairments, bigger participant populations, and the application and long-term retention of learned skills.

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