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The use of assistive technology to promote practical skills in persons with autism spectrum disorder and intellectual disabilities: A systematic review

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Abstract

Persons with autism spectrum disorder (ASD) and/or intellectual disability (ID) have difficulties in planning, organising and coping with change, which impedes the learning of daily living skills (DLSs), social participation and self-management across different environmental settings. Assistive technologies (ATs) is a broad term encompassing devices and services designed to support individuals with disabilities, and if used in a self-controlled manner, they may contribute inclusion in all domains of participation. This comprehensive literature review aims to critically assess and unify existing research that investigates the use of assistive technology within the practical domain for individuals with ASD and/or ID. The 18 relevant studies included in this review highlighted the benefits of AT for social participation and independence in daily activities of individuals with ASD and/or ID. Professionals working with this target group should be knowledgeable of the speedy progress of AT products and the potential of persons with ASD and/or ID to use mainstream devices to meet their individual needs. This awareness provides an opportunity to advocate for the universal benefits of AT for everyone. Technologies such as virtual reality, mobile applications and interactive software have been shown to improve DLSs, communication and social interaction. These tools offer engaging, user-friendly platforms that address the specific needs of these individuals, enhancing their learning and independence.

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Introduction

Initial problematisation

People with autism spectrum disorder (ASD) and those with intellectual disabilities (IDs) both face challenges in social participation.[1–4] Studies indicate that this population has fewer social participation opportunities than typical developing peers.[5] In this context, the literature refers to participation in various aspects of daily life (e.g., education,[6–9] social activities, spending time with family, friends[10–12] and recreational activities[11,13,14]) and in several stages of life (childhood, adolescence and adulthood). This is in line with the barriers faced by individuals with ASD and ID due to the impairments associated with their diagnosis. According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5),[15] both ASD and ID are classified as neurodevelopmental disorders, meaning that the disorders typically manifest early in development and are characterised by developmental impairments leading to limitations in personal, social, academic or occupational functioning. Specifically, the ID-diagnosis includes deficits in intellectual and adaptive functioning in conceptual, social and practical domains. Without ongoing support, the adaptive deficits limit functioning in one or more activities of daily life, such as communication, social participation and independent living, across multiple environments (home, school, work, and community). Regarding the ASD-diagnosis, the DSM-5 refers to persistent deficits in both social communication and social interaction and restricted repetitive behaviours. Symptoms cause clinically significant impairment in social, occupational or other important areas of functioning.[15] Adaptive skills are typically below those for measured IQ, which applies to persons with ASD with and without ID.[16] Difficulties in planning, organising and coping with change negatively impact academic achievement, even for students with above-average intelligence. In adulthood, individuals with ASD face difficulties in independent living and gainful employment.[15]

Common for ID and ASD is the impairment in individual adaptive functioning. Complying with a social-ecological view on disability, the level of functioning results from a dynamic interaction between a person's health conditions, personal factors and environmental factors.[17] Disability is not considered a characteristic of the individual but a problem of alignment between the person with functional limitations and abilities on the one hand and society on the other hand.[18] This way, the impact of the environment can be stimulating (enabling environment) or constraining (disabling environment), which may influence a person's full and effective participation in society on an equal basis with others.[19] Consequently, the emphasis shifts from a disorder or impairment in functioning to a need for support to perform activities and participate in society.[20] One of the enhancement strategies to address this need for support is the use of technology to strengthen cognitive, social and practical skills.[17,21] This comprehensive literature review aims to assess and unify existing research that investigates the use of AT within the practical domain for individuals with ASD and/or ID.

The knowledge gained will benefit the development of methodologies for AT applications to accommodate and facilitate practical skills. Emphasis is placed on user-centred design principles, ensuring that the technologies are tailored to meet the unique needs of individuals with ASD and ID. It highlights the integration of various disciplines such as psychology, computer science and engineering in developing assistive technologies. The review identifies a lack of standardised metrics for evaluating the effectiveness of ATs for ASD and ID. It proposes a framework for consistent assessment, facilitating comparative studies and evidence-based practice, and the need for cost-effective solutions that are widely accessible, particularly in low-resource settings.

The review also addresses some existing gaps in the research – notable deficiency in longitudinal studies that assess the long-term impact of ATs; the gap in training and support for caregivers and professionals using these technologies; and the need for better integration of ATs within existing educational and therapeutic frameworks – and discusses strategies for seamless incorporation, ensuring that these tools complement and enhance the traditional approaches.[22–24]

This review makes significant contributions by thoroughly analysing current ATs for ASD and ID, highlighting novel advancements and addressing critical gaps in the research. Its comprehensive and interdisciplinary approach, coupled with practical recommendations, paves the way for future innovation and improved outcomes for individuals with ASD and ID. This knowledge will be beneficial in the development of targeted tools that accommodate the individuals' needs for support in promoting practical skills.

Definition of the key concepts

Following the review aim, the four key concepts in relation to persons with ID and/or ASD are defined: (a) social participation, (b) adaptive functioning in the practical domain, (c) AT and (d) empowerment.

Social participation. Social participation refers to the involvement of individuals in activities and interactions within their community or society. It encompasses various forms of engagement, collaboration and contribution to a community's social, cultural, political or economic aspects. Social participation is a crucial aspect of a person's wellbeing and plays a significant role in building and sustaining a healthy, vibrant society. Participating in a diverse range of activities and experiences across life domains is central to the lives of all people, including people with ASD and ID.[25,26]

The World Health Organization (WHO)[18] defines participation as 'involvement in a life situation, influenced by the environment', which corresponds to the social model of disability. However, this definition focuses on the objective condition and does not adequately capture the subjective experience of involvement with others in society. Therefore, in research, the concept of social participation is frequently used. Notwithstanding the above, there is no single definition of social participation. Piškur et al.[27] identified three ways in which authors refer to social participation as a distinct entity: (a) as consumer participation (involvement in decision-making to increase wellbeing), (b) social activity (involvement in activities that provide interaction with others) and (c) levels of involvement in society (continuum from relatively passive to very active). Within the scope of this literature review, the term social participation is used as defined in the Quality of Life conceptual and measurement model, a widely used model in research with persons with ASD and ID as well.[2,28–30] Social participation, besides independence and wellbeing, is one of the three higher-order factors that constitute this Quality of Life concept. Each factor reflects multiple domains. Social participation is related to the following three domains: (a) interpersonal relations (social networks, friendships, social activities, interactions and relationships), (b) social inclusion (community integration/participation, community roles and supports) and (c) rights (human – respect, dignity, equality, legal access and due process).[28] This description is largely consistent with the interpretation of social participation[27] as a social activity because of its focus on interpersonal relationships and social inclusion.

Adaptive functioning in the practical domain. Adaptive functioning refers to an individual's ability to carry out everyday tasks necessary for self-sufficiency and independence. It refers to the person's ability to meet community standards of personal independence and social responsibility compared to individuals of similar age and socio-cultural background.[15] It is often assessed across various domains, including the practical skills or DLSs domain. For individuals with ASD and ID, adaptive functioning in the practical domain can be particularly challenging. To meet the demands of their environments, each person must learn a set of conceptual, social and practical skills. As environments change (e.g., in place, in time), people must learn new skills to continue to meet the environmental demands.[31] Examples of conceptual skills are literacy, concepts of numbers, money and time. Social skills may include interpersonal skills, social responsibility, self-esteem and social problem-solving. Practical skills involve learning and self-management across life settings, including skills such as personal care (e.g., hygiene, eating, dressing and household tasks), job responsibilities, money management, recreation, self-management of behaviour and school and work task organisation.[15,31–33] Thus, in both ASD and ID, a person-centred and individualised approach to adaptive functioning in the practical domain is crucial.

Assistive technology. AT refers to devices, tools, software or equipment designed to enhance the independence, functional capabilities and quality of life of individuals with disabilities. These technologies are intended to help people overcome limitations related to physical, cognitive, sensory or communication impairments. The WHO defines AT as 'assistive products and related systems and services developed for people to maintain or improve functioning and thereby promote well-being'[34] (e.g., wheelchairs, prosthetic devices, hearing aids, communication boards).[35] AT is an overarching term for products and related services used by persons with disabilities to enable and enhance their inclusion in all domains of participation. AT can be used by people of all ages, with all types of disabilities and all kinds of limitations in activities, for short or long periods.[36] AT can contribute to promoting access to education, employment, justice, health and wellbeing, as well as broader cross-cutting values of promoting social inclusion and participation, independence and autonomy, as well as leading a dignified and meaningful life.[37]

In recent decades, besides specially developed products for people with disabilities, there has been an emerging trend on developing mainstream products accessible to a broader audience, including people with disabilities.[35,36] There is an increasing focus on developing products according to the principles of Universal Design, Design for All, and Inclusive Design.[38–40] Among other things, techniques mainly used in ATs are being integrated into mainstream technologies (e.g., text-to-speech, speech-to-text, augmentative and alternative communication, navigation support apps and eye-gaze technology).[36,37] As such, mainstream technologies offer features that allow them to function as assistive products (e.g., smartphones, computers).[35,41] An assistive product can consequently be described as any

product, either specially designed and produced or generally available, whose primary purpose is to maintain or improve an individual's functioning and independence and thereby promote their wellbeing.[36] The field of AT continues to evolve, incorporating advancements in electronics, robotics and artificial intelligence to create innovative solutions that enhance accessibility and inclusion for individuals with disabilities. This technological evolution runs parallel to the paradigm shift from the medical model to the social-ecological model. While ATs have historically been developed to address the deficits of people with disabilities, there is a tendency to use ATs, and universally designed technologies in general, to support people to be active members of society.[42,43] Currently, there is an emerging trend of using participatory methods in AT development and research.[44,45] However, from a disability studies perspective, it is argued that research on AT is still mostly technical or therapeutic in nature and that the importance of AT deserves even more attention from social science disciplines.[42]

Empowerment. It refers to the process of enabling individuals or communities gain control over their lives, make informed decisions, and take action to improve their wellbeing. It involves fostering a sense of self-efficacy, confidence and autonomy. Empowerment can manifest in various aspects of life, including personal, social, economic and political domains. The term empowerment originated in the last century and was a central theme of civil rights associations, striving to give all people a voice, including marginalised groups.[46,47] Over time, the concept of empowerment has been explored in depth in multiple contexts and ecological levels: individual, organisational and community.[48–50] Empowerment can be seen as an open-ended construct that can vary by context or person, have a different meaning for each person and evolve over time.[50] Definitions of empowerment differ depending on the level or context in which the term is used. A common element in the definitions across time is that empowerment is a process. According to Zimmerman and Warschausky,[51] empowerment can be defined as 'processes and efforts that support people to gain control and influence of issues that concern them as well as to participate in decisions that affect their lives'. More recently, Haddad and Toney-Butler[52] defined empowerment as 'the interpersonal process of providing the proper tools, resources, and environment to build, develop, and increase the ability and effectiveness of others to set and reach individual goals'. The WHO[53] defines empowerment as 'the process by which people gain control over the factors and decisions that shape their lives. It is the process by which they increase their assets and attributes and build capacities to gain access, partners, networks, and/or a voice to gain control'.

Concerning the quality of life concept mentioned earlier in this introduction, empowerment is, besides skill development and involvement, one of the quality of life-related principles at the individual system level. Examples of enhancement strategies are decision-making, choice-making, risk-taking, goal-setting, self-advocacy and self-management.[17]

Empowerment is a dynamic and multifaceted concept that recognises the importance of addressing various factors contributing to individuals' ability to shape their lives. It plays a crucial role in fostering resilience, promoting social justice and building strong, vibrant communities.

Specific objectives and research questions

The specific objectives of the present review were (a) to systematically scrutinise and evaluate research studies delving into the applicability of ATs concerning adaptive behaviour within the practical domain for individuals with ASD and ID; (b) to gauge the influence of AT on the empowerment of individuals with ASD and ID, with a specific emphasis on its potential to promote self-management, independence and self-determination in daily activities and (c) to investigate the association between the utilisation of AT and the augmentation of social participation for individuals with ASD and ID. This encompasses its applicability and role in communication, community engagement and access to educational and vocational opportunities.

This analysis of the literature aims to answer the following three research questions: (a) What is the applicability of AT in facilitating behavioural adaptations related to practical skills in individuals with ASD and ID? (b) How does AT empower individuals with ASD and ID, enabling them to attain greater independence and make informed choices that contribute to their overall well-being? And (c) Does the incorporation of AT lead to improvements in social interactions, communication and participation within educational and occupational environments for individuals with ASD and ID?

Methods

We performed a methodological examination adhering to the PRISMA guidelines[54] (see PRISMA checklist, Supplementary File 1), encompassing peer-reviewed journal articles and full-text conference papers published in English from 2011 to 2021. Subsequent subsections explain the individual components of our approach in detail. The review was registered with PROSPERO (CRD42022350242). Briefly, we devised two sets of eligibility criteria, each applied at distinct stages of the review process. We employed a comprehensive approach for information retrieval, probing databases across various disciplines and adapting the search string for each database. The selection process encompassed nearly 3000 papers. The 18 studies selected for this

review were reviewed for quality and analysed using thematic synthesis and variables selected to address the formulated research questions.

Eligibility criteria

The eligibility criteria set 1 was established to include any study that (a) evaluated the effectiveness of interventions using AT, either alone or in combination with other tools; (b) involved individuals who had been diagnosed with autism and/or with ID and directly used the AT being investigated; (c) had applied empirical research designs, which could be quantitative, qualitative or mixed-methods, in any type of setting and (d) the outcomes measured were the effect of the AT investigated on any learning skill (e.g., reading, dressing) and, in turn, on the empowerment and social participation of people with autism people and/or with ID. The definitions provided in the introduction were considered to assess empowerment and social participation. Both primary and secondary outcomes on empowerment and social participation were deemed appropriate for a study to be included in our systematic review. Any study that did not meet these criteria was excluded.

Once the target skills of the studies were manually identified and classified according to the three domains described in the introduction (i.e., conceptual, social and practical) and the articles focusing on practical skills, which are the focus of our work, were selected, the eligibility criteria set 2 was established to exclude (a) AT-mediated intervention studies that included people with ASD and/or with ID who also had a comorbid sensory-motor (e.g., visual, auditory or motor) disorder; (b) AT-mediated intervention studies aimed at parents, professionals, employers, etc., instead of individuals with ASD or people with ID; (c) surveys or interviews on individuals with ASD and/or with ID's perspectives with no direct interaction with AT; (d) studies on the development of AT for therapists to evaluate children's behaviour and (e) studies on the use of ATs to empower family members or professionals working with individuals with ASD and/ or with ID, and not to them directly.

Information sources

Our systematic search was designed to thoroughly gather relevant studies from the following scientific databases: Web of Science, ACM Digital Library, IEEE Xplore, Scopus, EBSCO, APA PsycInfo, PubMed, Embase, ASSIA, Medline (Pubmed), CINAHL Complete, Education Resources Information Center (ERIC), Google Scholar and Allied and Complementary Medicine Database (AMED). The selection of these databases was made to encompass a wide range of disciplines, including technology, education, psychology, medicine and allied health, among others. Google Scholar and AMED were used to capture grey literature and complementary sources, ensuring a comprehensive approach to information retrieval.[55]

Search strategy

Our search strategy aimed to identify relevant studies by employing a systematic combination of keywords and controlled vocabulary terms. The Boolean operator "AND" was used to combine three concepts, and the Boolean operator "OR" was used to connect search terms within each concept. The search strategy included the following concepts and terms:

Concept 1. Intellectual Disability and autism-related terms: ("Intellectual* Disab*" OR "Intellectual* Impair*" OR "Intellectual* Retard*" OR "Intellectual* Handicap*" OR "Intellectual* Defici*" OR "Mental* Disab*" OR "Mental* Impair*" OR "Mental* Retard*" OR "Mental* Handicap*" OR "Mental* Defici*" OR "Learning Disabilit*" OR "Developmental Disorder" OR Autis* OR "Autism Spectrum Disorder" OR "Autism Spectrum Condition" OR "Asperger* Syndrome" OR "Pervasive Developmental Disorder") AND

Concept 2. Assistive Technologies related terms: (Technolog* OR Digital OR "Internet of Things" OR Computer OR "Electronic device" OR "Speech Generating Device" OR Wearable OR Smartphone OR iPhone OR Smartwatch OR iWatch OR "Mobile phone" OR Tablet OR iPad OR iPod OR Robot OR "Virtual Reality" OR "Augmented Reality" OR "Eye tracking" OR "Smart Glasses" OR "Artificial Intelligence" OR "Global Positioning System") AND
Concept 3. Empowerment and Inclusion: (empowerment OR inclusion)

Concepts 1 and 2 had to appear in the title, the abstract or the keywords, and Concept 3 could appear in any section of the article. The search string was adapted for each database to ensure compatibility with their specific requirements, ensuring a comprehensive retrieval of relevant literature.

Selection process

The flowchart in Figure 1 illustrates the selection process used for the final sample. The identification phase was conducted by implementing the search strategy to locate and retrieve data from the information sources. The results obtained through the 14 databases used ($n = 2909$) were transferred to Rayyan (https://www.rayyan.ai), an artificial intelligence tool to collaboratively work on systematic reviews, which facilitated the process of removing duplicates ($n = 1350$). During the first part of the screening phase, the eligibility criteria set 1 were applied focusing

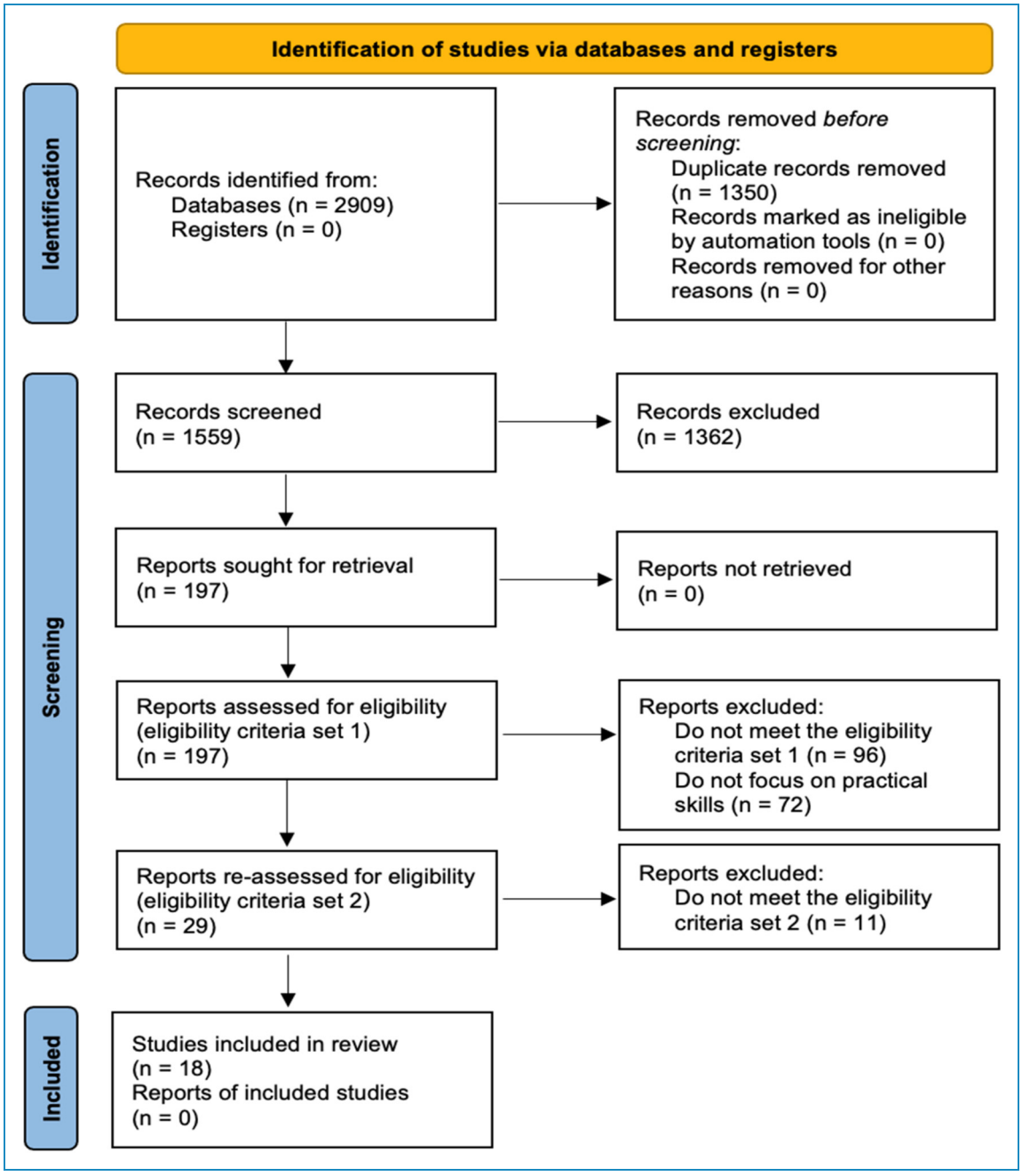

Figure 1. The selection process following the PRISMA 2020 updated guideline for reporting systematic reviews.[54]

exclusively on titles and abstracts. Then, 197 full-text papers were retrieved and assessed for eligibility according to the same set of criteria. As a result, 96 papers were excluded. The remaining 101 papers were then classified according to the three domains described in the introduction section: 72 papers focused on conceptual and/or social skills, and 29 papers focused on abilities, which included at least one practical skill. Given that this paper focused on practical skills, as described in the introduction, the corresponding 29 full-text papers were reassessed with the eligibility criteria set 2. After excluding 11 papers for not meeting these criteria, 18 studies were finally included in our systematic review.

Data retrieval

The 18 selected papers were thoroughly examined, and data were extracted for the following variables: (a) author(s) name(s) of the article, (b) year in which the article was published, (c) journal or conference title in which the article

was published, (d) characteristics of the participants included in the study (i.e., number, sex, age and diagnoses), (e) technology used (i.e., hardware (HW), software (SW) and its availability for the public), (f) which specific practical skill was targeted in the study, (g) research design applied, (h) characteristics of the intervention (i.e., length and intensity of the sessions, who implemented the study sessions and the setting in which the intervention took place and the country in which the intervention was implemented) and (i) the results obtained in the study about the effect of the intervention on both the practical skill(s) targeted and the social inclusion and/or empowerment of the participants included. These variables were selected to respond to the formulated research questions and allow us to discuss the matter reviewed thoroughly.

Quality assessment of the studies

All studies that met the eligibility criteria were reviewed for quality using the Critical Appraisal Skills Program (CASP) (see Tables 1 and 2). To ensure objectivity in the quality review, CASP reviews were first carried out individually, independently of each other, by three co-authors (ZP, KF and TØ). Then, each other's reviews were compared and discussed until a consensus was reached (ZP, KF and TØ). CASP assessment ranges from 0 to 10 for studies with qualitative design and for other designs from 0 to 12. Studies with 10 and 12 points are considered being of high quality. Studies with a quality assessment below 10 points were excluded to ensure validity and reliability. Meanwhile, none was excluded after the CASP assessment.

Data synthesis and analyses

To synthesise and analyse the data, studies were subdivided by the type of technology used and practical skill assessed. The narrative summary was used to discuss the experience of AT use for persons with ASD and/or with IDs in the practical domain. Thematic synthesis, as outlined by Thomas and Harden,[56] was employed for data analysis. This included extracting primary themes and subthemes from the studies included in the analysis. The focus of the discussions was limited to AT, specifically related to the practical domain.

Results

Study characteristics

Study characteristics are summarised in Table 3. The research described in the articles was conducted in different countries and continents. Seven studies were carried out in the United States (#1, 2, 5, 6, 11, 13 and17), two in France (#12 and16), and two in Great Britain (#15 and 18). One each was carried out in Norway (#3), Saudi Arabia (#4), Australia (#7), Canada (#8), Spain (#9), Brazil (#10) and Sweden (#14). Such international diversity reflects a global interest in understanding and implementing ATs for individuals with ASD and IDs in the analysed period.

No specific and global methodological trend emerged from the analysed papers. On the contrary, significant variation was observed in terms of research design. In the context of studies with small research samples, case studies dominated. In contrast, in the case of larger research samples, the research often had the character of an experiment with an intervention. However, it was rarely an experiment controlled by a control group. Moreover, many projects concluded the effects based on qualitative data, e.g., interview based. There were also mixed approaches in which the effects were diagnosed based on qualitative and quantitative data. Focus groups (with relatively small research samples) were also organised in several cases. It should be emphasised that there has yet to be a study with an identical methodology or any study in which previous procedures were replicated. Moreover, 22% were marked as a pilot study, i.e., one in which the sample needs to be bigger or there are no differentiated measurements and control conditions. All these studies are, therefore, complicated to compare and it is even more challenging to build convergent knowledge from them. Consequently, it is impossible to point out the statistics here (in the methodological area of analysis). Combining these observations with the differences in age and disability

Table 1. CASP assessment of included studies with qualitative design.

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Alanazi (2020)	Y	Y	Y	Y	Y	X	X	X	Y	X
Cumming (2014)	Y	0	Y	Y	Y	Y	Y	Y	Y	Y
Mintz (2013)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Wass (2020)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Note. CASP Checklist (Yes = 1; Can't tell = X; No = 0).

Table 2. CASP examination of pilot and intervention and feasibility studies.

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8a	Q8b	Q9	Q10	Q11	Q12
Backman (2018)	Y	Y	Y	0	Y	Y	Y	Y	0	X	X	X	Y
Canella-Malone (2012)	Y	Y	Y	0	Y	Y	Y	Y	0	Y	Y	Y	Y
Campos Panceri (2021)	Y	Y	Y	0	Y	Y	Y	Y	0	Y	Y	Y	Y
Evmenova (2019)	Y	Y	Y	0	Y	Y	Y	Y	0	Y	Y	Y	Y
Fage (2018)	Y	Y	Y	0	Y	Y	Y	Y	0	Y	Y	Y	Y
Kelley (2013)	Y	Y	Y	0	Y	Y	Y	Y	0	Y	Y	Y	Y
Kramer (2017)	Y	Y	Y	0	Y	Y	Y	Y	0	0	Y	Y	Y
Kossyvaki (2020)	Y	Y	Y	X	Y	Y	Y	Y	X	0	Y	Y	0
Lindsay (2016)	Y	0	Y	0	Y	Y	Y	Y	Y	X	0	Y	Y
Slocum (2022)	y	0	Y	Y	X	Y	Y	Y	X	Y	Y	Y	0
von Barnekow (2014)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	0
Wahlbrink (2022)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Vargo (2019)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Note. Y = Yes; X = No; 0 = Don't know.

of the participants, we can see that there is a great need to standardise procedures and emphasise on the publication of the definitive outcomes, presenting both the results of the pilot and the final research, with a detailed description of the participants and much larger groups representing the tested developmental disorder.

Setting and participants. The final research samples varied greatly in size. The average sample size was 17 people, but the standard deviation was as high as 16. In two studies, *N* was only 3. The largest *N* (two studies) was 48 (originally *N* = 50, but two participants were not included in the final analysis). The samples exhibited diversity also in terms of gender. For instance, some studies focused on males exclusively,[57–61,69,71–73] while others included a mix of males and females.[63–66,68,70] The age range was also diverse, ranging from children to adults, covering a broad spectrum of developmental stages. Most (nearly half) of the studies focused on teenagers, with an average age of 15, and the fewest studies focused exclusively on adults (only one study: 18–26 years) or only on children (two studies: 4–9 and 5–7 years). The second most common sample structure was a mix of teenagers and young adults (e.g., 14–22 or 16–25). There was also a structure, such as a mix of children and teenagers (e.g., 6–13 years old). The youngest participants were 4-year-olds, and the oldest were 26-year-olds. In two studies, it was impossible to determine the participants' age.

Most studies (39%) focused on people with ID. About 22% referred to individuals with ASD. Other papers included participants with diverse conditions, showing a comprehensive approach to intellectual disabilities. To be precise, 28% referred to ASD and ID, 6% (one study) to ASD and Down syndrome,[66] and another one to ASD, ID and Down syndrome.[61] Only some studies (less than one-fourth) specified (or considered in analyses) the severity, such as mild or moderate ID, which is an essential problem because including different severity levels and conditions contributes to a richer understanding of how ATs can cater to various needs.[1]

Settings ranged from public schools (Studies #1, 9, 11, 12, 15, 16, 17 and 18), university campuses (#2 and 7), sheltered workplaces (#3), home environments (#5 and 13), health care centres (#8 and14) and community locations (e.g., Starbucks) (#4, 6 and 10). The choice of diverse study locations ensured contextual relevance and practical insights into the implementation of ATs.

Major findings

Upon examining the outcomes of this review, the Evidence Standards Framework for Digital Health Technologies was

Table 3. Characteristics of participants, design, independent variables and assistive technologies in included studies.

Manuscript number	Authors	Country	Sample (*n* males), age range, gender	Type and severity of intellectual disability	Research design	Practical skill	Study location	Type of assistive technology (AT) and tier classification*
1	Vargo & Brown (2020)[57]	United States	*N* = 6 (6 males), age: 14–16 years	ASD	Multielement design embedded within a reversal design	Self-contained life skills classroom (disruptive behaviour reduction and preferences)	Public school, urban area, Texas	Computers, mobile apps, smart devices, Tier B
2	Kelley et al. (2013)[58]	United States	*N* = 4 (2 males), age: 18–26 years	ID	The experimental design was a multiple probe across participants design	Independent pedestrian navigation skills	Public, ac-credited university campus, rural community in southeastern United States	Video iPods, Tier B
3	Wass and Safari (2020)[59]	Norway	*N* = 9 (7 males), age: N/A	ID (mild or moderate)	Qualitative research design, including interviews	Use of photovoice	Taking pictures (while travelling), 3 sheltered workplaces (introduction and interviews)	Smartphones, Tier B
4	Alanazi (2022)[60]	Saudi Arabia	*N* = 9 (6 males), age: 22–25 years	ID (mild to moderate)	Focus group study	Using smartphone apps for transportation	Riyadh City	Smartphones, Tier B
5	Slocum and Ault (2022)[61]	United States	*N* = 3 (2 males), age: 12, 16 and 23 years	ASD, ID and Down syndrome	Multiple probe across behaviours design	Different community activity tasks	At home for one participant, and in the faith community for two participants	Tablet computer (iPad), Tier B
6	Wahlbrink et al. (2022)[62]	United States	*N* = 3 (2 males), age: 14–16 years	ASD	A multiple probe design	To acquire, maintain, and generalize interpersonal daily living skills (DLSs) in a community setting, for example to use interpersonal DLSs to order and purchase coffee and a snack	Four community locations including one Dunkin Donuts (training site) and three Starbucks (generalization sites)	Smartphones and earbuds, Tier B
7	Cumming et al. (2014)[63]	Sydney, Australia	*N* = 4 women and *N* = 4 academic researchers (three women, one man)	Intellectual disability (ID)	Multiple-case study approach	Research skills, including problem formulation, reflection, research planning, understanding research ethics, memorising, interviewing skills, and communication of results	School of Education, University of New South Wales and the Centre for Disability Studies, University of Sydney	iPads to support research skill acquisition, Tier B

(continued)

Table 3. Continued.

Manuscript number	Authors	Country	Sample (*n* males), age range, gender	Type and severity of intellectual disability	Research design	Practical skill	Study location	Type of assistive technology (AT) and tier classification*
8	Lindsay & Hounsell (2017)[64]	Canada (Toronto, Ontari)	41 participants including 18 youth (14 males and 4 females), 12 parents and 11 key informants Youth group aged between 6 and 13 years The junior group (aged 6–8 years) consisted of 10 children (nine boys, one girl) while the intermediate group (aged 9–13 years) consisted of 8 youth (five boys, three girls)	Autism spectrum disorder, cerebral palsy, spinal muscular atrophy, and developmental delays	Mixed methods pilot study- Pre- and post-workshop surveys, observations, and interviews	Practical skills related to computer programming and building robots were targeted in the adapted robotics program.	Bloorview Research Institute, Holland, Bloorview Kids Rehabilitation Hospital, Toronto, Ontario, Canada	The program involved the use of robotics construction kits, including LEGO MINDSTORMS EV3 and WeDo sets, to introduce students to science and technology. Tier B
9	vonBarnekow et al. (2017)[65]	Spain	Virtual training (Iteration 1): 5 females, 4 males; real-life experiment (Iteration 1): 2 females, 8 males; Virtual training (Iteration 2): 2 females, 4 males; Real-life experiment (Iteration 2): 4 females, 9 males; Participants were aged between 15 and 18 years.	Intellectual Disability (ID)	Pilot study with two iterations; Virtual training with IntegraGame followed by a real-life experiment	Vocational training for cleaning in a hostel	Taiga school and InOut hostel in Spain	3D-gamified simulation named IntegraGame, Tier B
10	Panceri et al. (2021)[66]	Brazil	The sample consisted of eight children. Gender distribution: one child with typical development (female), one with Trisomy 21 (female), and six children with Autism Spectrum Disorder (ASD), with one girl and five boys. Children were aged 4 to 9 years.	The study involved children with Down syndrome (Trisomy 21) and Autism Spectrum Disorder (ASD). Severity levels were not explicitly mentioned.	The study is described as a pilot study.	Psychomotor therapies for children with Down syndrome; psychosocial and cognitive therapies for children with autism spectrum disorder	Conducted partly in a countryside region and partly in a metropolitan area in Brazil.	Socially assistive robot named MARIA T21, Tier B
11	Evmenova et al. (2019)[67]	United States	The total sample included 52 students aged 18–27 years.	The group included an equal mix of IDs (50%) and ASD (50%) disabilities, comprising 83% males and 16% females with the mean age of 22 years.	The study used a mixed-methods design, including intervention and assessment phases. A cross-syndrome method was employed, comparing effects across populations	Functional academics, employment, residential/independent living skills, and auditing regular university classes	Inclusive postsecondary education (IPSE)	Iterative refinement of the technology prototype (smart watch) Tier B

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Table 3. Continued.

Manuscript number	Authors	Country	Sample (*n* males), age range, gender	Type and severity of intellectual disability	Research design	Practical skill	Study location	Type of assistive technology (AT) and tier classification*
					with different medical conditions.			
12	Fage et al. (2018)[68]	France	Tablet-ASD (Children with ASD using tablet applications): 14 participants (all males) Tablet-ID (Children with intellectual disabilities using tablet applications): 19 participants (9 males, 10 females) Control-ASD (Children with ASD not using tablet applications): 15 participants (13 males, 2 females) 50 participants aged from 12 to 17 years	The study included children with Autism Spectrum Disorders (ASD) and children with Intellectual Disabilities (IDs).	Pilot study with a 3-month intervention period. Three groups: Tablet-ASD, Control-ASD and Tablet-ID Pre- and post-intervention assessments	The mobile applications target socio-adaptive behaviours, social response in school settings, and socio-cognitive functioning of children with ASD and ID.	The study took place in French public secondary schools in the Bordeaux agglomeration.	The assistive technology included a package of mobile applications named 'School+' designed to support the inclusion of children with ASD in mainstream classrooms. Tier C
13	Kramer et al. (2017)[69]	United States	*N* = 42 (26 males) and 9 mentors (4 males); age: 14–22 years (transition age)	Intellectual and/or developmental disabilities	Qualitative and quantitative analysis of video calls, feasibility study	Interactions about barriers in physical and social environments, generate solutions to resolve barriers and request modifications to increase participation in a personal activity goal related to school, work or community participation (shopping, eating out, favourite school activities and getting a job)	At the home of participants	Phone or video chat technology (e.g., Skype), Tier B
14	Backman et al. (2018)[70]	Sweden	*N* = 28 (12 males); age 16–25 years	High-functioning ASD	Open within-group feasibility study	Feasibility in a clinical setting (participant attrition	Internet Habilitation Unit, Habilitation & Health	Internet-delivered coach-guided psychoeducational intervention, Spectrum COmputerized PsychoEducation (SCOPE), multimedia learning components, Tier C
15	Kossyvaki and Curran (2018)[71]	UK	*N* = 5 (4 males); age 5–7 years	Autism and ID	A case study	Engagement in education sessions	Primary special school	Cosmo hardware (a set of six switches which provide

(continued)

Table 3. Continued.

Manuscript number	Authors	Country	Sample (*n* males), age range, gender	Type and severity of intellectual disability	Research design	Practical skill	Study location	Type of assistive technology (AT) and tier classification*
								auditory (i.e., sounds and music) and visual cues (i.e., multicoloured lights), Tier B
16	Fage et al. (2016)[72]	France	*N* = 15 (10 males), age 13–17 years	ASD and ID	Participatory design	Activity schedules for both classroom and verbal communication routines	Secondary schools (special education classes)	Tablet-based application, named Classroom Schedule + (CS+), Tier B
17	Cannella-Malone et al. (2012)[73]	United States	*N* = 3 (2 males), age: 15 years	Moderate to profound ID	Adapted alternating treatments design within a multiple probe across participants design	Washing the table, sweeping	Self-contained urban school for students with moderate to profound ID and physical disability	iPod Touch, Tier C
18	Mintz (2013)[74]	UK	*N* = 8, age 12–18 years	ASD	Focus group interviews	Life skills (e.g., cooking, attending dentist, travel by public transport, organization routines, etc.)	Three mainstream UK secondary schools	A mobile phone app Helping Autism Diagnosed Navigate and Develop Socially (HANDS), Tier C

*Tier A = Digital Health Technologies that do not demonstrate measurable patient outcomes but provides services to the health and social care professionals; Tier B = Digital Health Technologies that provide information, resources or activities to the public, patients or health care professionals about a condition or general health and lifestyle; Tier C = Interventions to facilitate preventive behaviour change, self-management, treatment active monitoring, calculations that impact treatment, diagnose conditions.[75]

Table 4. Summary of the interventions, results, and impact on inclusion and wellbeing.

Manuscript number	Dependent variable	Intervention (yes/no), length	Providers of intervention	Outcome of the study	Impact of AT on inclusion/ empowerment
1	The dependent variables for the Intervention Group (IG) included baseline data related to disruptive behaviours.	Yes, three variations of the GBG (Good Behaviour Game) quasirandomly, one per day. Sessions were conducted five days a week during the 40-min math period in a self-contained life skills classroom. It does not provide specific details about the number and duration of sessions per day or week or the total duration of the intervention.	Teachers	GBG variations	The results indicate that all three GBG variations (traditional GBG, ClassDoJo GBG, and ClassBadges GBG) were effective in decreasing disruptive behaviours among students with autism.
2	Data were collected on two dependent variables: (1) correct and independent travel of a route to and from specified locations. (2) the percentage of correct pictured landmarks reached for each route.	Yes, video iPod training lasting fewer than 10 min per participant. Intervention sessions lasted approximately 15–30 min, four to five times a week, until all participants had entered and completed intervention with all three routes (number of weeks not specified). All participants continued navigating training routes for up to 232 days after intervention, using the video iPod.	Researchers	Navigating to and from a specified location without assistance from the iPod or researcher	Based on social validity data from participants, it appears participants felt explicit travel training allowed them to explore college activities to greater degree than they would have without instruction. Participants indicated they were more confident in their ability to travel independently, to other destinations on campus using iPod support.
3	N/A	No, but the qualitative research project design included: one moment for instruction, one day to take pictures (while travelling), one moment (= day after) for the interview (duration is not specified).	Researchers	N/A	The participants expressed a sense of meaningfulness and ownership. They viewed photovoice as an opportunity to contribute to something that could lead to a solution that could help themselves and others to travel independently.

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Table 4. Continued.

Manuscript number	Dependent variable	Intervention (yes/no), length	Providers of intervention	Outcome of the study	Impact of AT on inclusion/ empowerment
					Thus, the process of empowerment and the possibility of influencing the environment was articulated in the user needs that influenced the design of the prototype.
4	N/A	No, but in the qualitative research project, participants were split into three groups. Two focus group discussions were conducted for each group.	Researchers	N/A	Mobile apps can improve the mobility and foster social inclusion of persons with intellectual disabilities.
5	The percentage of independent responses on steps of the task analyses during probe and intervention sessions.	Yes, for each participant, the investigator conducted a minimum of five one-on-one probe sessions on the behaviours they would be learning (three tiers) prior to introduction of the independent variable.	Researchers	Level of response on all three task analyses within a faith community setting.	The intervention was successful in teaching people with ID to participate in community activities. Acquiring skills to participate in community settings, such as places of worship, will allow individuals with disabilities to participate in least restrictive environments, but acquisition of skills alone will not ensure inclusion.
6	Dependent variables were related to performance steps (a–d): (a) correct without support, (b) correct with support, (c) incorrect with support or (d) incorrect without support; and errors (a–c): (a) out of sequence errors, (b) latency errors and (c) performance errors	Yes, but the paper does not provide specific details regarding the length of the intervention sessions. But the whole experiment including the baseline, intervention and follow-up sessions lasted up to 23 days.	Researchers	Outcomes related to the use of interpersonal skills in the community	The results suggest adolescents can effectively generalise skills to other settings in the community. Acquiring and ultimately, generalising skills across community environments bodes well for promoting greater community inclusion.

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Table 4. Continued.

Manuscript number	Dependent variable	Intervention (yes/no), length	Providers of intervention	Outcome of the study	Impact of AT on inclusion/ empowerment
7	The dependent variables are not explicitly mentioned, but the study aims to examine the impact of using iPads as AT on the participation and empowerment of researchers with intellectual disabilities.	15 joint research training sessions, followed by 10 research meetings	The intervention is provided by an inclusive research team consisting of academic researchers and researchers with intellectual disabilities	The outcomes include the challenges and successes of implementing mobile technology. iPads are found to enhance participation opportunities for researchers with intellectual disabilities not only in research but also in other areas of their lives.	The study highlights the vulnerability of women with intellectual disabilities and the lack of control they often experience in their lives. The impact of iPads on inclusion and empowerment is emphasised.
8	The dependent variables are not explicitly stated in the text. However, the study aimed to understand the development and implementation of an adapted robotics program and the experiences of children and youth with disabilities within it.	Yes, there was an intervention in the form of the adapted robotics program. The length of the intervention was six 2-hour workshops held at a paediatric hospital.	Providers included clinicians, technical staff, and volunteers from FIRST Robotics Canada, as well as hospital staff.	The findings showed that adaptations made to the robotics program helped enhance the participation of children with disabilities. Children enjoyed the program and learnt about computer programming and building robots.	The study suggests a positive impact of the adapted robotics program on the inclusion and empowerment of children with disabilities in STEM-related activities.
9	Various metrics recorded during the evaluation, including correct actions, related actions, incorrect actions, virtual distance travelled, and time per action	Yes, intervention with IntegraGame in virtual training sessions Two iterations: Iteration 1 (April 2015) and Iteration 2 (June 2016) Virtual training involved playing four times in the first iteration and four times (2 per level of difficulty) in the second iteration	Developed in collaboration with a non-profit organisation, Icaria, and Taiga School	Noticeable difference between trained and non-trained students in real-life skills Positive feedback from educators and employers	Belief that 3D-gamified simulations like IntegraGame can be efficient tools to train social and professional skills of persons with intellectual disabilities, contributing to social inclusion through work

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Table 4. Continued.

Manuscript number	Dependent variable	Intervention (yes/no), length	Providers of intervention	Outcome of the study	Impact of AT on inclusion/ empowerment
10	Interaction outcomes measured using the Goal Attainment Scale (GAS)	Yes, the robot MARIA T21 served as an intervention tool. Length of the intervention was for two days, assisting half of the participants each day.	The intervention was facilitated by the robot MARIA T21, controlled by a group of researchers.	Encouraging results were reported based on outcomes obtained from the GAS. The study aimed to demonstrate that the use of MARIA T21, combined with Serious Games is an innovative and promising tool for conducting therapies with children with ASD and Down syndrome.	The study suggests that MARIA T21 has the potential to provide greater engagement and interaction in therapies, promoting social interaction between the robot, child, and therapist.
11	The dependent variables included measures related to socio-adaptive behaviours, social response in school settings, and socio-cognitive functioning.	The intervention involved a 3-month deployment of tablet-based assistive and training apps named 'School+'.	The text does not explicitly mention the specific providers of the intervention. It refers to co-design work with stakeholders, including families, school staff and therapists for the development of applications.	The main results indicated improvements in socio-adaptive behaviours, social response in school settings, and socio-cognitive functioning for children with ASD.	The intervention based on 'School +' applications showed promising results in supporting the inclusion of children with ASD in mainstream classrooms.
12	The study measures improvements in socio-adaptive behaviours, social response in school settings, and socio-cognitive functioning.	Yes, the intervention involved the use of mobile applications ('School+') for a 3-month period. The applications included both assistive apps (for compensatory purposes) and cognitive training apps (for remediation purposes).	The school aides and teachers were involved in supporting the use of the mobile applications during the intervention.	Tablet-ASD children showed improvements in socio-cognitive functioning, socio-adaptive behaviours (social skills, school skills, leisure), and social response (motivation and repetitive behaviours). Tablet-ID children also exhibited improved performance on the assessments at the end of the intervention.	The results suggest that the intervention using 'School+' applications allowed participants with ASD to be more included in mainstream classrooms for better social participation.

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Table 4. Continued.

Manuscript number	Dependent variable	Intervention (yes/no), length	Providers of intervention	Outcome of the study	Impact of AT on inclusion/ empowerment
13	Mentee attendance and engagement	12 weeks with eight peer-mentoring calls	Persons with ID/ DD	Mentees participated in 87% of scheduled calls and actively engaged in 94% of the call objectives. Among all mentoring pairs, mentors successfully accomplished 87% of the objectives, and a noteworthy correlation was observed between the utilisation of supports (such as mentoring scripts and direct supervision) and the fidelity of the mentoring process.	Transition-age mentees with intellectual and developmental disabilities (I/DDs) can participate in electronic peer mentoring to enhance their problem-solving skills. Trained mentors with I/DD can facilitate electronic peer mentoring with the assistance of qualified personnel, ensuring the provision of necessary supports and personalised job accommodations.
14	Feasibility and treatment satisfaction	February 2015 to September 2016 (weekly contact)	disability service professionals (trained coaches)	23 out of the 29 included participants (79%) completed the intervention. The participants' experience of treatment credibility was increased during the SCOPE web course and the overall satisfaction with the treatment was high. The coaches reported high treatment credibility and good clinical feasibility of the internet-based delivered intervention. The participants' knowledge of ASD increased significantly from pre intervention to post intervention. The increased knowledge of ASD was not associated with negative effects on psychological wellbeing.	To inform and educate older adolescents and young adults with ASD about different aspects of ASD – strengths as well as common difficulties and impairments, so as to enable empowerment through psychoeducation. This type of intervention can help to improve knowledge about ASD without adverse side effects.

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Table 4. Continued.

Manuscript number	Dependent variable	Intervention (yes/no), length	Providers of intervention	Outcome of the study	Impact of AT on inclusion/ empowerment
15	Engagement level and social communication skills, including behaviour regulation, joint attention and social interaction	Two 12 min weekly sessions for 5 weeks	A newly qualified teacher (NQT) and four teaching assistants (TAs)	Some positive outcomes, especially regarding social communication skills, are reported, which are of significant value to educational researchers and school staff.	Use of school-based technology mediated music-making interventions to promote engagement levels and social communication skills for children with autism and ID
16	Classroom routine and verbal communication	3 months	A school aide, inclusion teachers, special education teacher	All children with ASD successfully adopted the application, whereas children with ID did not reach an autonomous use. The two groups (with ASD and ID) exhibited different patterns of benefits. Children with ASD largely increased their socio-adaptive behaviours on both classroom and verbal communication domains, while children with ID improved only on nonverbal classroom routines. CS+ by children with ID enhanced their autonomy in performing classroom routines in general inclusive classrooms.	interface organisation, interaction duration and idiosyncratic contents have played a key role in the adoption of the AT while ensuring the child's effective presence in the classroom

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Table 4. Continued.

Manuscript number	Dependent variable	Intervention (yes/no), length	Providers of intervention	Outcome of the study	Impact of AT on inclusion/ empowerment
17	Percentage of steps completed correctly; the percentage of steps requiring error correction; number of sessions required to reach criterion	190 individual sessions (3–8 sessions/week). The study compares the use of video prompting with and without error correction using the iPod.	Independent observers and trainer	All three students improved their performance over baseline levels, but only two students met mastery using video prompting with error correction for table washing	The study focused on the use of simple technology to improve daily living skills (sweeping and table washing) among adolescents with moderate to profound ID. Video prompting is an effective technology for teaching new skills to individuals with moderate to profound ID.
18	the potential use of the technology to support the inclusion of children with ASD in mainstream secondary schools	NA	NA	the potential for smartphone technology to foster the development of social and life skills, independence of children with ASD and thus promote their inclusion in mainstream settings	Smartphones help some children with ASD in developing social and life skills.

adopted.[75] As shown in Table 4, it is evident that no Tier A studies were found in our review. Most identified studies were categorised as Tier B ($n = 14$), while the remaining were classified as Tier C ($n = 4$). This allows us to categorise AT solutions into levels and summarise their types. Tire B primarily focuses on solutions based on computers, smartphones and tablet computers. However, there may be instances where alternative hardware solutions, such as earbuds or socially assistive robots, are also included. For example, Kossyvaki and Curran[71] implemented special hardware with six switches which provide auditory (i.e., sounds and music) and visual cues (i.e., multicoloured lights), demonstrating positive outcomes of engagement levels and social communication skills of 5–7 years old children with autism and ID at school (#15). Four studies (#3, 4, 6 and 13) used smartphones and phone applications to improve communication in the community and foster social inclusion by increasing independence in using public transportation. Wass and Safari[59] concluded that photovoice facilitated the understanding of the individual and contextual experiences of participants with ID and that they could make decisions according to their preferences. Alanazi[60] presented results of the focus group demonstrating strong support for using the Careem and Uber apps to enhance the confidence of persons with ID in navigating various locations. Additionally, this study's findings suggested that these apps are gaining popularity among individuals with ID as they progress in the learning process on how to use them. Wahlbrink et al.[62] reported that using the Apple iPhone 6s equipped with the List Recorder application demonstrated improved interpersonal DLSs and effectively used the mobile device as a prompting system for three participants with ASD. The observed generalisation of effects indicates that the participants' behaviours continued to show improvement even after the intervention. Kramer et al.[69] reported that individuals with ID, serving as both peer mentors and mentees, can effectively engage in structured mentoring relationships through phone calls and video chats.

Computer- or tablet-based applications were implemented in four studies (#1, 5, 7 and 16). According to Vargo and Brown, technology-enhanced Good Behaviour Games (GBGs), namely ClassDoJo GBG, led to reductions in disruptive behaviours in high school students with ASD.[57] Slocum and Ault demonstrated that the use of video modelling (VM) in combination with the system of least prompts (SLPs) was effective in teaching three individually selected behaviours to three individuals with ID and ASD for participation in a faith community.[61] iPads were used to support researchers with ID to improve their research skills and contribute to their social lives. Fage et al. showed that the 'School+' applications empowered individuals with ASD, enabling them to enhance their sociocognitive functioning.[72] Two studies (#8 and 10) implemented robotic technologies. Lindsay and Hounsell examined the development of an adapted robotics program, suggesting positive effects on social interactions, communication and participation within educational environments.[64] Panceri et al. introduced a socially assistive robot with integrated serious games, emphasising encouraging results in child–robot interactions and social engagement.[66] Both studies involved young children (age 4–13 years) with ASD, Down syndrome and other IDs.

One study used gamified vocational training simulation (#9) to demonstrate positive outcomes, as users recognised real-life scenarios and attempted to apply what they had learnt.[65]

The study of Evmenova et al. (#11) presented stakeholders' feedback, including young adults (18–27 years) with ASD and ID, on the technology prototype (application for the smartwatch) usability to facilitate learning and self-regulated behaviours in academic inclusive postsecondary education (IPSE).[67]

Tier C studies (#12, 14, 17 and 18) primarily addressed software solutions (phone apps, video chat and mobile applications). All studies discussed the improvement of social and life skills of persons with ASD and ID. Three out of four studies aimed to promote the use of assistive technologies in education settings. A study by Fage et al. assessed the impact of a tablet-based application on social interactions and socio-adaptive behaviours, suggesting positive effects in the mainstream classroom for children with ASD and ID.[68] Also, parents reported high usability, indicating that the applications were well-received in daily life environments. Cannella-Malone et al. directly addressed the incorporation of AT (video prompting with an iPod Touch) leading to improvements in skill acquisition (sweeping and table washing), with implications for communication and participation in individuals with moderate to profound ID.[73] Smartphone technology fosters the development of social and life skills and independence of children with ASD and thus promotes their inclusion in mainstream settings.[74] The study by Backman et al. was implemented by the Internet Habilitation Unit, Habilitation & Health at the municipality council in Stockholm (Sweden), demonstrating that internet-delivered coach-guided psychoeducational intervention, Spectrum Computerized PsychoEducation (SCOPE), was feasible to increase knowledge of ASD and themselves.[70]

Next is the summary of study outcomes related to each research question from the data extracted.

RQ1: Applicability of ATs for facilitating behavioural adaptations related to practical skills.

Ten studies demonstrated the applicability of AT to benefit behaviour adaptations related to practical skill outcomes in individuals with ASD and ID. Three studies (#2, 3 and 4) aimed to improve independent use of transportation and travel to novel locations. The study outcomes

indicated positive results across interventions. For example, 15- to 30-min intervention sessions four to five times a week, implementing video iPod training, improved independent travel skills for young adults with ID.[58] Furthermore, the practical skills needed for independent travel were demonstrated in two qualitative studies implementing photovoice[59] and smartphone apps, such as Uber and Careeem,[60] for young adults with moderate to severe ID. ATs have been shown to contribute to behavioural adaptations across different environments (schools, public sites, faith communities and homes). For example, in Vargo and Brown, the daily use (40 min of math session) of technology-enhanced GBGs was shown to lead to reductions in disruptive behaviours in high school students with ASD.[57] von Barnekow et al. demonstrated the applicability of 3D-gamified simulations as vocational training tools for adolescents with ID to learn practical skills related to hostel cleaning.[65] In Fage et al., a technology-based system (CS+) for children with ASD significantly increased socio-adaptive behaviours in both classroom and verbal communication, while improvements among children with ID were only established during non-verbal classroom routines.[72] VM on iPad combined with SLPs effectively taught three individually selected behaviours to individuals with ID and ASD for participation at home and in faith communities in the United States.[61] Similarly, in home environments, phone or video chat technology (e.g., Skype) was effectively used for structured mentoring relationships through electronic communication for individuals with ID serving as both peer mentors and mentees.[69] An Apple iPhone equipped with the List Recorder application demonstrated improvement in interpersonal DLSs and effectively used the mobile device as a prompting system for individuals with ASD in public places (e.g., Dunkin Donuts, Starbucks).[62]

RQ2: The impact of AT on empowering individuals with ID and ASD.

Transportation and navigation were among the most notable domains where using AT was particularly beneficial. Specifically, three studies highlighted that AT, mainly through picture prompts on iPod,[58] photovoice[59] and using the Careem and Uber apps, can increase travel independence in individuals with ID to enable participation in activities outside the home. In addition, other studies showed that AT may enable people with ID and ASD to be independently involved in activities across different environments, for example, in church[61] and educational settings.[65,72] Also, AT can empower individuals with ID enabling them to serve as peer mentors.[69] Regardless of the domain where AT was used, enhancing the empowerment of individuals with ID and ASD appeared to be closely linked to respecting their needs and desires, thus strengthening their capacity for independent decision-making, providing opportunities for them to take responsibility over their lives and fostering their active social participation.

RQ3: The role of AT in facilitating communication, social interaction and participation in educational and occupational environments.

Fifteen studies showed that AT can improve the social interactions of individuals with ID and ASD, contributing to the development of their communication skills with friends, colleagues at work locations and community members (e.g., at faith community), and enhance their social life.[57,60–62,64–74] For example, the use of robotic programs enhanced the ability to understand and participate in scientific activities[64] and therapy sessions[66] promoting social interactions. AT can be used to improve the ability to learn new life skills, for example, sweeping and table washing following video prompting in individuals with severe and profound ID,[73] cooking, attending the dentist, using public transport by using mobile phones in school-age children with ASD,[74] purchasing meals following recorded audio messages on mobile phone[62] and performing occupational skills by using 3D gamified simulations.[65] The research evidence demonstrated beneficial effects in decreasing social isolation among individuals with ID and ASD.[60,61,67,68]

Discussion

This comprehensive literature review aimed to assess and unify existing research that investigates the use of AT within the practical domain for individuals with ASD and/or with ID. The analysis of the literature led to answering the three predetermined research questions. Despite the limited number of publications, evidence could be demonstrated through various studies for each research question. This systematic review included 18 studies addressing the use of AT contributing to social participation and community engagement of individuals with ASD and/or with ID.

Overall, empirical evidence indicates that interventions employing AT are potentially beneficial in enhancing engagement levels in the educational processes (e.g., reduction of disruptive behaviours, improvement of socio-cognitive functioning), improving social communication skills (e.g., joint attention, social interaction), increased independence in using public services (e.g., public or commercial transportation, shopping and church), learning vocational skills (e.g., cleaning services) and fostering social inclusion.

The complexity of the practical domain has resulted in the application of various research designs across the selected studies. The criteria for evidence of effective practices have been established to guide researchers in following the quality indicators for selected research designs.[76]

Only four of the selected studies met all the quality indicators and can be defined as high-quality research designs.

This literature review broadly used the term 'assistive technology'. Both technologies designed specifically for the target group and mainstream technologies were included. This reflects the growing trend towards universal design, where mainstream products become accessible to a broader audience, including people with disabilities.[35,36] Most of the studies used mainstream smartphones, computers or tablet computers. A few studies included alternative hardware solutions such as earbuds,[62] switches with visual and auditory cues[71] or socially assistive robots.[64,66] In terms of software, both commercial and bespoke software were used (e.g., iMovie,[61] Classroom Schedule+ [72]). Mainstream software was also used to develop specific applications (e.g., PowerPoint[58]). This review echoes previous reviews demonstrating a noticeable transition in the nature of AT over the past decade, replacing handheld computers with portable electronic devices like iPods, iPads and smartphone applications.[77,78] The shift towards more advanced technology is evident throughout the studies in this review. For instance, video prompts are provided on iPods and iPads, and navigation instructions are provided on smartphone apps. The trend of using portable electronic devices as ATs has contributed to removing social boundaries between mainstream technology and AT, as many individuals without disabilities use smartphones daily.[79] Moreover, when individuals with ASD and/or ID perceive AT positively rather than as a tool to mitigate disability-related challenges, it can promote social participation and a sense of belonging in the community.[80] Overall, the variety of target behaviours and skills to which AT was used throughout the reviewed studies illustrates the strong potential that these technologies can play in supporting individuals with ASD and/or ID across different settings and life situations.

As the first research question focused on studies that aimed to strengthen the adaptive skills of people with ASD and/or ID in the practical domain,[15,31] results are described as outcomes on DLSs across different environments (e.g., independent travel,[58] vocational training,[65] interpersonal DLSs[61]). Applications were also used as a prompting system for learning and self-management across life settings.[61,73] This ties in with the second research question concerning the impact of AT on empowering individuals with ASD and/or ID. The included studies showed that AT could be seen as a tool to build, develop and increase the ability of people with ASD and/or ID to set and reach individual goals (e.g., independent involvement in multiple environments).[79]

With 15 out of 18 studies showing that AT can improve social interactions in people with ASD and/or ID (e.g., contribution to communication skills in several environments[71] and participation in social life[62]), the third research question was also positively addressed. This is significant given that people with ASD and/or ID often face challenges in social participation.[1,4,5] Not least because social participation can be seen as a crucial aspect of a person's well-being. These studies collectively underscore the diverse ways in which AT positively impacts social participation, communication and inclusion within educational, occupational and different community environments.

This review provides practitioners and policymakers with numerous recommendations on how to maximise the benefits of AT for persons with ASD and/or ID. First, educators, therapists, trainers and assistant personnel should learn to use AT in various social environments and settings as part of their professional development. For example, integrating AT in implementing individual education plans can be essential to support inclusive education practices.[81] Second, partnerships between special schools, social care institutions or NGOs and information technology companies should be encouraged to generate user-friendly and cost-effective solutions that address the needs of people with ASD and/or ID.

Finally, it is vital to design and implement national and international policies requiring the incorporation of AT in public services and educational institutions, for example, free Wi-Fi access, accessible and user-friendly infrastructure (e.g., ticket machines for public transportation). Furthermore, improving public space infrastructure to facilitate AT use is important, such as establishing Wi-Fi in public locations and ensuring that public service systems are compatible with various AT devices.[82,83]

Limitations

Despite the positive results, some critical comments on the limitations of this review should be made. First, the wide variation in study designs and the number of participants involved made it difficult to compare studies and build convergent knowledge. Moreover, one-fifth of the studies were pilot studies, demonstrating only preliminary results. The second limitation of the reviewed studies is that six of the 18 studies did not mention whether or not the software was commercially or publicly available. Four other studies definitively used a prototype. Third, there was the heterogeneity of the participants across the reviewed studies. In addition to the difference in the age range, there was also a difference in the participants' adaptive functioning levels. Since an individual's level of adaptive functioning is the result of the person's health status, personal factors and environmental factors,[17,18] this varies for each individual. Although some studies specified the severity of ID (e.g., mild or moderate ID), there was little to no consistency in the way the adaptive functioning of the participants was described. A more accurate characterisation of the participants would provide more insights into the use of AT in relation to the various support needs of the target group.

Finally, this review consists only of studies published in the English language. Thus, some relevant studies published in other languages might be overlooked. These limitations highlight the need for ongoing research, personalised approaches and better access to resources to optimise the use of AT for skill development in this population.

Relevance of studies

Despite the limitations, the reviewed studies are replicable in different vocational, educational or community settings. While many studies evaluating the applicability of AT were in the development phase, the simple research designs enabled teachers, vocational skill trainers or other professionals to obtain pre- and post-intervention data across various environments. Most of the interventions implied a limited number of tasks or steps, simplifying the data collection process. Overall, the review outcomes are promising: most of the AT solutions used in studies led to positive outcomes in facilitating the independence of people with ASD and/or ID in performing relevant daily activities and increasing their independence.

Recommendations for future research

This systematic review has identified important directions for future research and potential ways in which ATs should be considered and can be integrated to enable individuals with ASD and/ or ID to accomplish practical tasks of daily life, enhancing their social participation. Additionally, this review highlighted challenges encountered in prior research, providing valuable feedback for prospective investigations. Future research should implement interventions that consider the affordances of the applied ATs, conduct comprehensive evaluations of research designs and incorporate one or more components related to the technology quality indicator. Emphasis should be placed on the exploration of mainstream technologies and service models offering features that allow their use as assistive products to enhance the social inclusion and participation of individuals with ASD and/or ID. It is important to be meticulous about technological advances and harness their potential for empowering individuals with ASD and/or ID. On the other hand, previous studies have also proved that specifically designed applications for people with disabilities inspire the universal design of products that most people can use. Therefore, future interventions should include target groups and service models identified and explored in previous feasibility or pilot studies described in this review. It is recommended that people with ID and/or ASD, as experts by experience, should be even more directly involved in the research and development of (assistive) technologies. To this end, participatory development and research methods are appropriate.

Conclusions

In conclusion, this systematic review highlighted the benefits of AT for social participation and independence in the daily activities of individuals with ASD and/or ID. Professionals working with this target group should be knowledgeable of the speedy progress of AT products and the potential of persons with ASD and/or ID to use mainstream devices to meet their individual needs. In turn, this provides an opportunity to advocate for the universal advantages of ATs for all.

This systematic review on the use of AT to promote practical skills in individuals with ASD and/ or ID reveals promising outcomes. Technologies such as virtual reality, mobile applications, and interactive software have been shown to improve DLSs, communication and social interaction. These tools offer engaging, user-friendly platforms that cater to the specific needs of these individuals, enhancing their learning and independence. The review highlights the importance of integrating technology into educational and therapeutic practices to support skill development in this population. Also, this review addresses researchers from underrepresented communities, particularly those with direct experience with persons having intellectual challenges or psychosocial disabilities. This overview extends to voices of disability rights activists or leaders of grassroots initiatives whose contributions are vital for fostering an inclusive discourse.

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