Using Participatory Design to Develop Communication-Supporting Technology: A Scoping Review

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Abstract. *Building on and updating foundational reviews from a decade ago, this scoping review synthesizes Participatory Design (PD) practices in the design of communication support systems for neurodivergent children. Focus is given to interdisciplinary frameworks, technological outputs, and the reported experiences of children engaged in the process via PD. Findings indicate the emergence of bespoke PD methods informed by a complex interplay between child development and computer science. Children's experience of PD and technology impact are dependent on individual capability and access to support networks. Most tools are designed for remediation, at times incorporating playfulness and gamification for sustained motivation. Future work should prioritize participant diversity, provide transparency in reporting theoretical foundations, and incorporate robust validation of design outputs.*

1. Introduction

United Nations International Children's Emergency Fund (UNICEF) defines communication as the ability to share meaning and exchange information through mutual understanding [United Nations Children's Fund (UNICEF) 2022]. This encompasses expressing opinions, making requests, and sharing viewpoints via verbal and non-verbal means, such as gestures and turn-taking. As childhood development of these skills is vital for academic attainment, social inclusion, and wellbeing, effective support like Speech and Language Therapy (SLT) requires coordinated effort from education sectors, health services, parents, and the child. Participatory Design (PD) has been proposed as a means to maintain motivation during challenging interventions by recognizing the child's agency and lived expertise. By positioning the child as a design partner rather than a passive subject, PD aims to create contextually relevant and motivating tools.

This paper advances the field by synthesizing research on PD for neurodiversity affirming communication support. Building on foundational reviews by [Benton and Johnson 2015] and [McNaney et al. 2018], we provide an updated baseline of research from the last decade to identify current trends, research gaps, and methodological limitations. Communication-supporting technologies represent a particularly critical area of focus, as communication difficulties are among the most commonly reported barriers to social inclusion and educational participation for neurodivergent children [Law et al. 2021], yet remain underexplored within PD literature.

To avoid positioning groups in relation to a neurotypical standard [Benton et al. 2014], or allistic norms [Monk et al. 2022], we use the term neurodivergent children when referring to our target population. This term acknowledges the diversity of children whose neurological development and functioning differ from typical expectations. Neurodivergence encompasses a range of neurodevelopmental differences affecting the brain and nervous system, including, but not limited to, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), language disorder, and dyslexia [American Psychiatric Association 2022].

Technology can support communication for neurodivergent people by offering accessible and flexible digital interventions that have shown promising benefits for skills such as expressing needs, responding to others, and taking part in social interaction [Zorzi et al. 2025]. Despite these gains, research often overlooks the child's perspective [Law et al. 2021]. Involving children in design acknowledges their agency and aligns with their rights under the United Nations' Convention on the Rights of the Child [United Nations General Assembly 1989]. When it comes to digital interventions, a promising approach to foster child involvement is through PD; a methodology positioning end-users as active design partners [Schuler and Namioka 1993]. Rather than being studied from a distance, users contribute their expertise and perspectives through various techniques (e.g., prototyping, storyboarding) to ensure solutions meet their everyday needs.

Previous foundational reviews of participatory design with neurodivergent children by [Benton and Johnson 2015] and [Börjesson et al. 2015] identified no communication support studies before 2006 and only five between 2006 and 2014. All were reported in ACM venues, with some also appearing in parallel publications in discipline specific journals. Looking beyond Human Computer Interaction (HCI) specific sources, [Law et al. 2021] conducted an extensive review of digital interventions for children with communication disabilities using databases across health, education, psychology, linguistics, and the social sciences. Their review considered end user involvement yet did not identify any studies in which children contributed to the design. This suggests that child involvement in the design of communication support technologies was either limited or not captured within adjacent intervention literature. Returning to the studies that were identified, while the reviews noted the value of the PD experience, they highlighted limited transparency about the theoretical frameworks shaping PD methods. This absence obscures the rationale for design decisions, hinders replication, and limits critical engagement with how such tools may inadvertently enforce neurotypical norms.

Our work updates and extends existing reviews by systematically synthesising studies involving neurodivergent children in designing communication technology within the HCI literature. We consider the technology produced, validation methods, and the reported outcomes of the PD process. We report on the theoretical models that informed the design phase. Our review aims to address the following research questions: (**RQ1**) What theories and approaches have informed methods to in-volve neurodivergent children in the PD of communication support technology?, (**RQ2**) What are the technological outputs created from involving neurodivergent children in the PD of communication support technology?, and (**RQ3**) What has been the experience for neurodivergent children of being involved in PD?

2. Methodology

An interdisciplinary team, comprising a registered Speech and Language Therapist and HCI academics experienced in neurodiversity, conducted this review to address its cross-sectional research questions. We employed a scoping review methodology to map the landscape of research involving neurodivergent children in communication technology development [Arksey and O'Malley 2005]. This approach is ideal for exploring the nature and range of research activity in emerging, heterogeneous fields, rather than evaluating intervention effectiveness as in traditional systematic reviews [Peters et al. 2020]. Guided by established frameworks, the review identifies theoretical PD foundations, technological outputs, and participant experiences to highlight interdisciplinary gaps. The protocol followed the PRISMA-ScR extension [Tricco et al. 2018], focusing on the ACM Digital Library to map the HCI landscape, with citation searches used to expand coverage.

2.1. Eligibility

We included studies that fully met the following predefined criteria:

- **Participants:** Selected studies included children of school age (4-16 years old) presenting with a neurodevelopmental disorder based on criteria from DSM-5 [American Psychiatric Association 2022].
- **Study type:** As we aimed to review PD approaches, children must have been involved in the design process.
- **Output:** Studies that reported on the development of communication support technology as an outcome.
- **Language:** Articles included in this review were limited to those published in English.
- **Range in years:** Studies conducted between 2006 and 2023, commencing from the earliest eligible study identified in existing systematic reviews meeting the inclusion criteria. This timeframe provides a snapshot of the field prior to the shift toward large language model-based interventions.

For the initial ACM abstract search conducted in December 2023, the following thesaurus terms were entered into the ACM search engine. These terms were selected to cover the literature on PD techniques to design communication support systems for children.

- disab* OR impair* OR delay* OR difficult*
- child* OR infant* OR pediatric*
- therap* OR intervention* OR instruction* OR treatment* OR teaching OR learning OR support*
- Lang* OR social* or communica* OR interacti*
- design OR develop*
- particapa* OR accessabl* OR usab* OR inclus*

2.2. Data Selection

Using the eligibility criteria, the first and second authors independently selected papers and then compared them for consistency. Any unsure items where consensus could not be reached were deferred to the third author for a final decision. The fourth author provided general oversight. The paper selection process was two-stage: Titles/abstracts and full-text review. Stage 1 involved reviewing all of the titles and abstracts from the deduplicated list of articles identified from the database searches, and allocating an initial classification to each study of either:

1. "Included" which went through to Stage 2 of the process (these seemed likely to meet the eligibility criteria)
2. "Unsure" whether it should be included or excluded based on the title/ abstract (these still went through to Stage 2)
3. "Excluded" from Stage 2 process (these did not meet the eligibility criteria)

Stage 2 repeated the above process but with a focus on full-text items. Reference lists of all full texts were manually reviewed for further articles.

2.3. Data Collection Plan

The study data was managed and processed through COVIDENCE Software [Veritas Health Innovation 2023]; a web-based collaborative platform tailored for empi-rical reviews. A template was designed to capture essential data points aligned with the research questions, specifically: (1) author details and publication year; (2) participant demographics, including count, age range, gender distribution, and diagnosed conditi-ons; (3) PD methodologies, activities, and session details; (4) study outputs, validation methods, and technologies utilized; and (5) children's outcomes and experience measures.

2.4. Analysis plan

A mixed methods analysis was employed, organising the extracted data into thematic groups and presenting through descriptors and inter-rater agreement, using both textual representations and diagrams. Further analyses were conducted through subgroup exami-nations following established scoping review guidance [Peters et al. 2020] to explore the influence of various study characteristics, including: **Participant characteristics, Study design, Technology validation, Children's experience.**

3. Results

The following section presents the results of our analysis, structured according to our research questions. The search strategy identified 13 papers, marked with an asterisk in the reference list. As some papers reported findings from the same study, these papers represented 8 unique studies that met the eligibility criteria. The scoping selection process is illustrated in Fig 1.

3.1. Study Demographics

This section synthesizes the participant profiles across the eight unique studies. Across the studies identified, participants spanned a **wide age range**, with the youngest being 4 years old and the oldest reaching 14 years of age. The **gender distribution** shows a significant skew and lack of reporting. One study exclusively included male participants [Malinverni et al. 2014], three had a mix of male and female participants [Frauenberger et al. 2011, 2012, 2013], [Frauenberger et al. 2019, Makhaeva et al. 2016] and [El Shemy et al. 2023], and one featured solely female participants [de Faria Borges et al. 2012, de Faria Borges et al. 2014]. Moreover, gender diverse individuals were not included. Notably, in 38% of the studies, gender was not specified [Benton et al. 2014] [Millen et al. 2011a, 2011b] [Wilson et al. 2020], highlighting a need for more transparent demographic reporting in PD research. Regarding **diagnosis**, there is a lack of participant heterogeneity. Five studies solely involved neurodivergent children with autism (total $n = 39$) [Malinverni et al. 2014], [Frauenberger et al. 2019, Makhaeva et al. 2016],

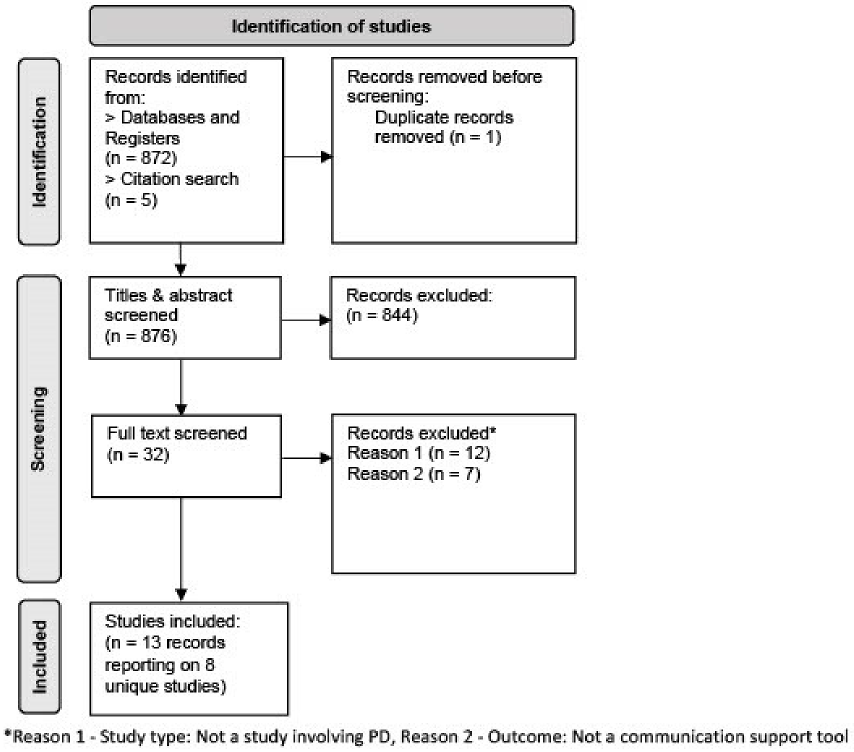

Figure 1. Study Selection Process

[Millen et al. 2011a, 2011b], [El Shemy et al. 2023], [Wilson et al. 2020]. One study recruited across multiple conditions including autism and undiagnosed social/language difficulties ($n = 3$) [Frauenberger et al. 2011, 2012, 2013]. Only two studies explored other neurodivergent profiles: [Benton et al. 2014] involved children with dyslexia ($n = 4$), and [de Faria Borges et al. 2012, de Faria Borges et al. 2014] worked with a child with cerebral palsy ($n = 1$).

3.2. Theories and approaches directing the technology design process

Table 1 provides detailed findings addressing RQ1. Findings demonstrate that the PD methods and activities used to involve neurodivergent children in the reviewed studies were informed by established thinking from both child development and computer science.

Child development: Four studies referred solely to educational and therapeutic approaches specific to the neurodevelopmental conditions of the participants, such as autism-specific programs (e.g., TEACCH [Mesibov et al. 2005], SCERTS [Prizant et al. 2006], Play theory [Vygotsky 1976]). In two studies, the PD approach was influenced by theories of typical neurodevelopment, including language acquisition, psycho-social development, and learning through play [de Faria Borges et al. 2012, 2014], [Malinverni et al. 2014]. Two further studies were influenced by work relating to both typical and neurodivergent development [El Shemy et al. 2023], [Wilson et al. 2020].

System design: Approaches found include DSD [Bekker and Antle 2011], PLEX cards [Lucero and Arrasvuori 2010], and Diversity for Design (D4D) [Benton et al. 2014]. [de Faria Borges et al. 2012, 2014] incorporated core software development principles through the Incremental Model of Software Development Cycles [Sommerville 2011], organizing the design into cycles of needs analysis, construction, and assessment. The study reported in both [Frauenberger et al, 2019] and [Makhaeva et al. 2016] referred to D4D framework [Benton et al. 2014] and strategies for creative contributions developed by [Malinverni et al. 2014].

Table 1. RQ1: Theories and PD Methods

Paper	Guiding theories and approaches	PD methods and activities
[Benton et al. 2014]	**Child Dev:** TEACCH. **System:** CI, Inclusionary Model, Fictional Inquiry.	**Method:** D4D framework. **Role:** Verbal, drawings. **Loc:** School. **Dur:** 3 workshops.
[de Faria Borges et al. 2012, 2014]	**Child Dev:** Thinking for Speaking, Syntactic cues. **System:** Inclusionary CI, Incremental Dev.	**Method:** PD4CAT. **Role:** Physical interaction, drawings. **Loc:** Rehab/school.
[El Shemy et al. 2023]	**Child Dev:** Instruction theory, Multimedia Learning, Weak coherence. **System:** DSD, PLEX cards.	**Method:** cARd toolkit. **Role:** Verbal. **Loc:** School. **Dur:** 20-30min.
[Frauenberger et al. 2011, 2012, 2013] Note: Frauenberger et al. [1011, 2012] focuses on PD processes and Frauenberger, et al. [2013] focuses on system validation.	**Child Dev:** SCERTS, Social stories. **System:** CI, Fictional Inquiry, Toolkit.	**Method:** PD Theory/Practice. **Role:** Interaction, writing. **Loc:** School. **Dur:** 5 sessions.
[Frauenberger et al. 2019; Makhaeva et al. 2016]	**Child Dev:** Exec dysfunction, Pretend play. **System:** CI, Drama, Digital Fab, D4D.	**Method:** Action-Play-Space. **Role:** Tailored methods. **Loc:** School/Uni. **Dur:** 10-20 sessions.
[Malinverni et al. 2014]	**Child Dev:** Psychosocial dev. **System:** Edu design, Informant design.	**Method:** PD for empowerment. **Role:** Drawings, puppet shows. **Loc:** Hospital. **Dur:** 5 wks.
[Millen et al. 2011a, 2011b]	**Child Dev:** TEACCH. **System:** Cooperative Inquiry (CI), Virtual edu env, Fun Toolkit.	**Method:** Structured scenarios. **Role:** Verbal feedback. **Loc:** School. **Dur:** 1hr.
[Wilson et al. 2020]	**Child Dev:** Play theory, Sensory processing, Abstract reasoning. **System:** CI.	**Method:** Co-Design Beyond Words. **Role:** Physical/social interaction. **Loc:** School gym. **Dur:** 40 wks.

Note: Loc=Location, Dur=Duration. TEACCH=Treatment and Education of Autistic and related Communication-handicapped Children, CI=Cooperative Inquiry, DSD=Developmentally Situated Design, SCERTS=Social Communication, Emotional Regulation, Transactional Support.

3.2.1. Involvement of Children

The extent of child involvement varied across studies. While most designs were influenced by children's physical and social responses in predefined contexts like structured play, the study reported by [Frauenberger et al. 2019] and [Makhaeva et al. 2016] allowed children to choose contexts based on personal interests. Similarly, [Wilson et al. 2020] derived design information from child-led, primarily non-verbal play episodes. Other studies utilized direct conversation to capture thoughts and experiences [de Faria Borges et al. 2012, 2014], [Benton et al. 2014]. In contrast, [Malinverni et al. 2014] by-passed contextual inquiry, as experts pre-identified educational goals; here, children participated by transforming these fixed goals into playful experiences.

With the exception of the study [Wilson et al. 2020], children provided specific design suggestions using verbal feedback, drawings, stories, and/or crafting depending on designer preference, child engagement, and the nature of the solution being designed. [Wilson et al. 2020] created opportunities for self-expression such as introducing playful materials and engaging in games and these were used to inspire design ideas. Some sessions with the children were one-off activities: [El Shemy et al. 2023] and [Millen et al. 2011a, 2011b], whereas others extended over several weeks [Malinverni et al. 2014] and [Frauenberger et al. 2011, 2012], or months [Frauenberger et al. 2019, Makhaeva et al. 2016] and [Wilson et al. 2020]. The single PD session reported in [Millen et al. 2011a, 2011b] was preceded by information gathering from experts who knew the children and PD sessions with typically developing children. The rationale being that this would enable a more constrained and focused approach that is more likely to encourage neurodivergent children to participate, engage, and benefit from the activity.

[Frauenberger et al. 2011, 2012] and [Malinverni et al. 2014] aligned their sessions to existing social skills groups at the children's school or clinical site, aiming to create meaningful social learning tools for participants. [Makhaeva et al. 2016], [Frauenberger and Makhaeva 2019], and [Wilson et al. 2020] employed a holistic child-led approach spanning numerous sessions, while [de Faria Borges et al. 2012, de Faria Borges et al. 2014] emphasized keeping sessions short and focused to prevent distraction. Most studies occurred in the children's school, and this appeared to be related to convenience, familiarity for the child, reduced disruption to routine, and ease of access to physical and professional support structures. All of the designers engaged with carers, health professionals, and/or teachers to gain support with planning, delivery, and/or analysis of findings.

3.3. Tools designed using PD

Table 2 details the tools designed through PD, whether they were evaluated, and what findings emerged, to respond to our RQ2.

Tabela 2. RQ2: Outputs Of Participatory Design

Paper	Output	Evaluation	Findings
[Benton et al. 2014]	VR Lang/Literacy	No	N/A
[de Faria Borges et al. 2012, 2014]	Assistive AAC tool	Usability/Role-play	Children found strategies to improve system.
[El Shemy et al. 2023]	AR word learning	In development	N/A
[Frauenberger et al. 2011, 2012, 2013]	VR Social env.	Design Critique	Triggers: modify behavior, add items, gamification.
[Frauenberger et al. 2019, Makhaeva et al. 2016]	DSmart, ThinkM, Sound cube	Qualitative	Pride in design; ThinkM had low post-collab use.
[Malinverni et al. 2014]	VR Social game	In development	N/A
[Millen et al. 2011a, 2011b]	VR social learning	No product	N/A
[Wilson et al. 2020]	Tangible AAC ball	Video Interaction Analysis	Engagement via movement and creativity.

3.3.1. Outputs: Systems and Solutions

[Benton et al. 2014], [Malinverni et al. 2014], and [Millen et al. 2011a, 2011b] used PD to design game-based learning tools. We consider the definition of games as outlined in [Tekinbas and Zimmerman 2003]: a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome. Rather than full game experiences, these tools employed **gamification** [Deterding et al. 2011a, Deterding et al. 2011b], leveraging points and rewards to incentivize compliance with therapeutic tasks.

In [Malinverni et al. 2014] and [Millen et al. 2011a, 2011b], games used Virtual Reality (VR) as a controlled environment to improve social skills through set goals, whilst [Benton et al. 2014] targeted language and literacy. [Frauenberger et al. 2011, 2012, 2013] and [Wilson et al. 2020] designed child-led play-based tools focused on creativity without predetermined goals. Frauenberger et al. utilized play-based VR for social exploration, while Wilson et al. designed a tangible Augmentative and Alternative Communication (AAC) ball enabling self-expression through sensors. In the study reported by [Frauenberger et al. 2019, Makhaeva et al. 2016] PD outcomes included tools based on individual interests, supporting language and social skills. [de Faria Borges et al. 2012, 2014] designed an assistive AAC tool for a minimally verbal child. [El Shemy et al. 2023] used augmented reality (AR) for vocabulary learning, positioning the social context as the motivator rather than gamification.

3.3.2. Evaluation of Designs and Systems

Four studies [Wilson et al. 2020], [Frauenberger et al. 2011, 2012, 2013], [Frauenberger et al. 2019, Makhaeva et al. 2016], [de Faria Borges et al. 2012, 2014] evaluated the tools designed through PD. Of the studies that did not evaluate, [Malinverni et al. 2014], [Millen et al. 2011a, 2011b], and [El Shemy et al. 2023] stated that this was because there was no product yet produced, whilst [Benton et al. 2014] did not give an explanation for not reporting on system evaluation. [de Faria Borges et al. 2012, 2014] undertook detailed usability and accessibility testing, using expert-informed methods including role play and structured free-testing, with feedback used to iteratively improve the system.

[Frauenberger et al. 2013] developed a novel annotator tool to gain user feedback and adopted an established feedback methodology known as design critique [Blevis et al. 2007]. A frame over the virtual environment solution allowed children access to a pen and emotion stamps: smiley, frowny, confused for feedback. The evaluation approach was trialled to ensure it was acceptable for the children. The study reported by [Frauenberger et al. 2019Makhaeva et al. 2016] provided limited descriptive evaluation of one tool from the range of systems designed. They referred to heterogeneity in participants' profile and the variety of tools designed making consistent evaluation difficult.

[Wilson et al. 2020] used an established analysis method to evaluate their method, Video Interaction Analysis [Jordan and Henderson 1995], with a focus on social and physical interactions stimulated by the solution. This approach was in keeping with the minimal verbal profiles of the participants and findings were validated by the experts supporting the children enabling appropriate system refinement.

3.4. Experience of participants

As detailed in Table 3, five of the reviewed studies reported on participant experience [Benton et al. 2014], [Malinverni et al. 2014], [Millen et al. 2011a, 2011b], [Frauenberger et al. 2019, Makhaeva et al. 2016], [Wilson et al. 2020]. [Frauenberger et al. 2019, Makhaeva et al. 2016,] and [Millen et al. 2011a, 2011b] used unstructured descriptions to report children's positive and negative experiences of PD. [Millen et al. 2011a, 2011b] offered reflections on the source of the negative experiences to guide future considerations. [Malinverni et al. 2014] and [Benton et al. 2014] also critiqued negative experiences of PD, however, these reflections were more structured as both studies adopted frameworks for analysing participant experience. [Wilson et al. 2020] uniquely developed design goals based on participants' existing positive experiences, proposing that this would lead to engaging design solutions.

Table 3. RQ3: Experience of Participation

Paper	Method	Experience Findings
[Benton et al. 2014]	Diversity4Design framework	Distraction by resources; need for dyslexia-friendly fonts and uncluttered space.
[Frauenberger et al. 2019, Makhaeva et al. 2016]	Unstructured descriptions	Enthusiastic in creating prototypes; valued completion over high-fidelity.
[Malinverni et al. 2014]	Suitability, capability, empowerment	Preferred blank templates; excitement and pride in drawings. Story-boards were not enjoyed.
[Millen et al. 2011a, 2011b]	Unstructured descriptions	Positive interaction; initial reluctance to drawing was overcome. Personas caused confusion.
[Wilson et al. 2020]	Observations	Children gravitated toward balls; enjoyment expressed via utterances/sounds.

4. Discussion

We present a review of synthesized evidence on PD for neurodivergent children's communication technology. Identifying only eight studies from over 800 papers highlights the limited evidence available to designers, clinicians, and educators. Despite this scarcity, the emerging trends and their implications offer a valuable guide for future research and practice.

4.1. Homogeneity in Participant Groups and Dissemination

It is worth noting six of the eight studies recruited children with autism specifically. The tendency to target autism in PD studies has also been reported by related reviews [Benton and Johnson 2015, Börjesson et al. 2015], confirming that this bias has persisted over the past decade without meaningful change. Possible reasons include prevalence within the general population and convenience sampling by recruiting through autism specialist services, which are more widely available than for other conditions. In addition, the communication needs of children with autism tend to be around social interaction skills rather than with forming language structures, particularly with those that are described as "high-functioning" by the current literature [Tóth et al. 2022]. As a result, there is greater capacity to provide design feedback without significant expert scaffolding and support, which is often appealing for design activities. However, caution must be taken given that, as demonstrated by Benton et al. [Benton et al. 2014], PD methods from the autistic population cannot be directly genera-lised to other neurodevelopmental disorder populations. As such, PD studies involving a range of neurodevelopmental diversity is needed and should be prioritised in future research. Parallel to this, only one study was published in a disability focused journal in addition to a computer science output [Millen et al. 2011a, 2011b], while the remaining studies were disseminated only through computer science venues, limiting reach and impact.

4.2. Theory-informed Design

The presented review reveals a complex interplay between interdisciplinary theoretical frameworks and evidence-based approaches in PD for neurodivergent children. PD methods are shaped by influences spanning child development, psychology, software de-sign, and HCI to create context-specific activities responding to individual needs. By merging theoretical models with practice-based insights, these approaches recognize how system-level factors (family, school, and community) influence development. Consequently, designers often involve parents, teachers, and clinicians alongside the child to account for diverse learning preferences, sensory processing, and communication styles. This multi-stakeholder engagement helps mitigate challenges inherent in involving children with communication difficulties. The emphasis on ecological context aligns with Bron-fenbrenner's bioecological model [Bronfenbrenner and Morris 2006], which focuses on the dynamic interactions between a child and their surrounding systems. Many studies mirror this by engaging both the child and their support networks, ensuring solutions are developmentally appropriate and grounded in daily routines.

4.3. Technology Solutions Produced

This review suggests that communication technologies for neurodivergent children tend to be designed to support children's learning within a remedial lens. Most examples approached technology as a way to teach skills where children needed support, of-ten aiming to align communication with neurotypical standards rather than prioritizing child-led autonomy. This remediation focus is consistent with what prior reviews found [Benton and Johnson 2015, Börjesson et al. 2015], indicating that the field has yet to shift meaningfully toward leisure-oriented or child-directed design goals. Gamification and playfulness to maintain motivation were incorporated in the majority of solutions. This finding complements existing literature reporting positive effects on speech outcomes and attention [Saeedi et al. 2022]. However, consistent with critical HCI perspectives, studies also report boredom, frustration, and low self-esteem if gamification elements are not en-gaging or are overly restrictive [Ahmed et al. 2018, Rubin et al. 2014]. Successful design therefore requires balancing the level of challenge, game mechanics, and interface attrac-tiveness to ensure playfulness supports expression rather than just compliance. These are useful design factors for future work in this area.

4.4. Validation of the System

Half of the identified studies did not report on evaluation of the designed communication tool. In some cases, this was because of the early stage of the prototype, whilst other studies focused more on the process of the design rather than the output. Where studies did conduct testing, methods lacked standardized metrics and tended to be internally developed, involved those who participated in the design, and were often qualitative in nature. Whilst this provides insight into the design priorities of those creating the systems and bespoke local benefits, it does limit the extent to which inferences could be drawn with regards to generalization of gains to the wider population of neurodivergent children.

4.5. Extent of Child Involvement

Children's contribution and experience of the design process are influenced by a range of factors across the bioecological system. These include the expectations and expertise of the design team, the children's profile of strengths and needs, and the physical and social support available. Many studies discuss the importance of balancing creative opportunities with structured approaches, referring to the fine interplay between empowering and overburdening. [Frauenberger et al. 2011] highlight that beneficence is paramount in this context, ensuring that the demands placed on children do not outweigh the benefits of their inclusion. The importance of achieving this balance is evident when reading participant experiences of the design process. Negative experiences reported across the reviewed studies reflect expectations exceeding capacity, underscoring the importance of matching activities to individual capability and ensuring the experience is genuinely empowering [Malinverni et al. 2014].

4.6. Recommendations

Drawing on the recurring limitations and gaps identified across the preceding subsections, we propose the recommendations for future PD research shown in Table 4.

Table 4. Strategic Recommendations for Future PD Research

Focus Area	Recommendation
Diversity	Prioritize inclusion of children with a broader range of conditions beyond autism to improve generalizability and report in cross-discipline outputs
Theory	Ground methods in interdisciplinary frameworks (e.g., Druin's model, Bronfenbrenner's theory) to bridge domains.
Adaptation	Use AAC-aligned strategies and stakeholder support (parents, clinicians) for diverse profiles.
Beneficence	Balance creative opportunities with scaffolding to empower children without overwhelming them.
Design	Use gamification for motivation; prioritize leisure autonomy alongside remediation.
Validation	Integrate systematic validation to demonstrate the impact and effectiveness of PD outputs.

5. Limitations

This scoping review is subject to limitations that impact the generalizability of the synthesized trends. First, the search was restricted to the ACM Digital Library and manual citation searching. This was appropriate for a focused mapping of PD practice, particularly as earlier communication support studies in this area were all reported in ACM venue reviews. However, more recent relevant studies in adjacent health or education literature may have been missed. The use of broad search terms may have introduced noise during initial screening, though the two-stage selection process helped mitigate this. Second, the search window concluded in December 2023. This specific end date provides a methodological baseline of the decade prior to the widespread integration of Large Language Models (LLMs), ensuring the review focuses on the fundamental participatory techniques rather than the emerging novelties of generative AI. Finally, as the review was limited to English-language publications, it potentially overlooks culturally specific participatory methodologies used in non-Anglophone regions.

6. Conclusion

This review highlights the growing potential of PD to develop inclusive communication technologies for neurodivergent children. A key strength is integrating interdisciplinary approaches driven by theory, drawing on child development, HCI, and bioecological perspectives to tailor methods to individual needs. While gamification effectively sustains engagement, it requires careful design to prevent frustration or the enforcement of neurotypical norms. Notable limitations in the field include the overrepresentation of autistic participants, a focus on remediation rather than leisure directed by children, and underspecified system evaluations. Ultimately, balancing creative input with children's capabilities is essential to avoid overburdening them. By synthesizing this complex interplay between child development and system design, this work provides a critical foundation enabling designers, researchers, and therapists to prioritize participant diversity and truly empowering solutions over neurotypical remediation.

7. Acknowledgement

This research was made possible through funding from the Natural Sciences and Engineering Research Council of Canada (NSERC) Discovery Grant RGPIN-2023-36100. We thank the Faculty of Computer Science at Dalhousie University for their support.

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