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Systematic Mapping of Co-Design and Participatory Design with Preschool Children: Techniques, Roles, and Methodological Challenges

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Abstract. Computing is everywhere, and children observe, use, and are affected by the technology around them. They must understand the ”digital world” as they understand the ”real world”. Involving them in collaborative design processes can increase their engagement and understanding of technology and allow children to learn. However, there is a notable gap in understanding how preschool-aged children (4–6 years old) can be effectively involved, and existing studies often focus on the products children create during these processes. We conducted a Systematic Mapping (SM) study of research published between 2015 and 2025, reviewing 34 empirical studies involving children aged 4–6 using Participatory Design or Co-design methodologies. This SM synthesizes the following information: year of publication; retrieval sources and databases; publication outlets and locations; time frame of the research; research approach; and, finally, participants and those responsible for the study. Our analysis reveals a growing interest in involving preschool-aged children in design, with various techniques employed to engage them. However, there is a lack of standardized methodologies adapted to this age group, and few studies examine learning outcomes for the children involved.

Keywords: Co-design, Participatory design, Early Childhood, Preschool, Systematic Mapping

1 Introduction

Computing has become an integral part of our lives, impacting everything from how we retrieve information to how we communicate. Children are no exception to this trend. No matter their surroundings, they are exposed to and influenced by the technology surrounding them. Digital natives are growing up in a world heavily shaped by computers and must navigate it fluently [Al Majali, 2020].

Even before they are literate, children learn to use most resources available through electronic devices randomly without having a specific objective [De Paiva and Costa, 2015]. Although children are surrounded by technology, children often remain passive users of technology [Fischer and Scharff, 2000] and are unable to create, modify, or actively participate in technological solutions. Despite being surrounded by digital tools, they frequently lack an understanding of how these technologies are created or manipulated and are unaware of how they might leverage them to solve real-world problems.

For individuals to develop their skills and use technology effectively, they must understand and engage with the “digital world” just as they do with the physical one [García Aretio *et al*., 2019]. This underscores the increasing importance of children learning about technology from a young age, with the support of adults [Rose *et al*., 2017].

Although current literature highlights the importance of involving children in the design process to improve their understanding and engagement with technology, very little has been done to map and study initiatives for younger children. Lehnert *et al*. [2022] study was a systematic review that provided an overview of how interaction design methods were carried out with children aged 0–18. While the work presents important contributions to the field, it summarizes that children of all ages participated, but the main focus was on those aged 7-13. To date, no studies have been found that address how collaborative design was carried out with preschool children.

While this growth in the literature has advanced some insights into young children introduced in the collaborative design process, little is known about the characteristics base inform this developing body of knowledge. For example, what ages of children are being included in collaborative design processes, and what roles? What are the techniques used in this process? And what are the other participants in the process? Considering these concerns, this systematic review of the literature is predicated on the need to better understand the characteristic knowledge base of the collaborative design with preschool children. The research question informing is: *How is the Co-design and PD process carried out with preschool-age children?*

We conducted a Systematic Mapping Study encompassing research published between 2015 and 2025. We searched several databases, including ACM (Association for Computing Machinery), IEEE (Institute of Electrical and Electronic Engineers), ScienceDirect, Scopus Elsevier, and Springer, using predefined inclusion and exclusion criteria to ensure the relevance and quality of the selected studies. The criteria focused on empirical studies involving children aged 4 to 6 in the design process using Participatory Design (PD) or Co-

design methodologies. Our mapping synthesized 34 studies, from which we collected information such as year of publication, sources and databases, publication venues and locations, the temporal scope of the research, research approaches, and details about participants and researchers involved.

Our results reveal several key findings that contribute to the state of the art. We observed increased publications over recent years, indicating a growing interest among researchers in involving preschool children in the design process. Seventeen different techniques were identified as being used in the studies, such as Comicboarding, Cooperative Inquiry, and Storytelling, although almost half of the PD studies (47.5%) did not clearly describe the methods used. Most studies included children in the roles of informants or users, while the role of design partners, considered the most inclusive, was adopted by only 8 of the 34 studies analyzed. In addition, a diversity of application contexts was found (schools, laboratories, homes), but in approximately 31% of the studies this information was not reported.

These findings highlight the potential and the methodological and practical challenges of including young children in Co-design and PD processes. We have gained a clearer understanding of current practices and challenges in involving preschool-aged children in collaborative design, knowledge that was previously fragmented in the literature. Our study provides insights into effective techniques and highlights gaps where further research and methodological development are needed.

2 Background

The PD and Co-design approaches actively involve end-users in product, service, and technology development [Howard and Somerville, 2014; Huybrechts *et al*., 2017]. These approaches have their roots in the tradition of participatory action research, which seeks to promote collaboration and co-creation between designers and stakeholders. Co-design and PD are collaborative approaches to design.

PD and Co-design approaches have been widely used as collaborative methodologies for creating technological and pedagogical solutions. PD stands out for its emphasis on democratic inclusion and user empowerment, particularly in contexts in which decisions directly impact participants. This approach is characterized by the application of methods such as collaborative workshops and participatory prototyping, which allow stakeholders to actively contribute to all project phases [Ehn, 2017]. Co-design emerges as a more comprehensive evolution of this perspective, extending its application to various domains, such as education, health, and technological innovation. Focusing on collective creativity, Co-design uses playful and iterative tools to integrate the voices of multiple actors in the development of innovative solutions aligned with the specific needs of the groups involved [Sanders and Stappers, 2008].

Despite sharing the goal of promoting active participation, PD and Co-design differ in their premises and applications. PD focuses on design process democratization, positioning users as co-decision makers [Muller, 2003]. On the other hand, Co-design emphasizes the construction of communities of practice by fostering a sense of belonging and collaboration among participants, who act as creative partners in the co-creation process [Baranauskas *et al*., 2013]. This approach facilitates the generation of innovative technological solutions and reinforces shared learning and the creation of collaborative networks. Thus, while PD has a more formal character and focuses on equality of power in decision-making, Co-design adopts a more exploratory and inclusive stance, allowing greater flexibility and creativity in academic and research projects.

In collaborative design studies with children, it is common to adopt the typology proposed by Druin [2002], which classifies children's roles into four main categories: users, testers, informants, and design partners. This classification has become a standard in the field because it provides a clear structure for analyzing the various levels of participation. However, contemporary authors have questioned its limits, especially when analyzing contexts in which participation does not fit into these categories. For example, de Morais *et al*. [2024] propose the recognition of intermediate roles, which arise from specific contextual conditions and challenge the deficiency of the traditional model. This discussion is particularly relevant to this work, which seeks to understand how children aged 4 to 6 were involved in Co-design and PD processes described in the scientific literature.

Co-design and PD with children, particularly when involving physical artifacts, expands the scope of their involvement beyond digital systems. Artifact-based design enables children to engage both tactilely and imaginatively, providing opportunities to integrate their lived experiences into the design. For instance, creating tangible tools or toys involves problem-solving and decision-making that align with their developmental stages and contextual knowledge.

Such approaches broaden the design landscape, allowing children's perspectives to inform diverse domains, including educational tools, play materials, and even urban spaces. Collaborative design processes are a valuable practice that benefits both children and the outcomes of the design process. Expanding this participation to include the creation of artifacts opens new avenues for engagement and innovation.

Including young children in these processes, however, presents challenges. It is necessary to adapt methodologies, materials, and language to their capacity for attention, understanding, and symbolic expression, which may require additional time, resources, and careful planning [Van Mechelen *et al*., 2017]. Managing children's expectations about implementing their ideas is also critical, ensuring they understand that not all contributions can be realized [Kapanen *et al*., 2019]. Furthermore, there is a substantial gap in the literature regarding the standardization of techniques and the systematization of how these methodologies have been implemented with this specific audience.

Although some methodologies, such as Cooperative Inquiry [Druin, 2002] and Comicboarding [Hiniker *et al*., 2017], are cited in studies with young children, it is still unclear how they are adapted to the preschool age group. Equally important, many studies focus on the products generated by children, neglecting procedural aspects such as the roles assumed by them, the contexts of application, and the forms of mediation adopted by adults. The absence of a consolidated

view on these dimensions motivated the development of this systematic mapping, which seeks to synthesize evidence on how children aged 4 to 6 have been involved in Co-design and PD processes, identifying techniques, roles assigned to children, and the main methodological challenges faced.

3 Related Work

The inclusion of children in the technology design process is a recurring theme in child-computer interaction research. Alhatem *et al*. [2019] conducted a literature review on participatory design with children, focusing on children with visual impairments. The study highlights that PD can have a positive impact when including children with disabilities in the design process, allowing them to act as partners in technology development. Additionally, the work suggests that while there are different approaches and methods to engage participants during the design process, there is a lack of standardization in methodological choices and strategies for adapting methods to specific groups, such as children with visual impairments.

In the context of applied games, also known as serious games, Saiger *et al*. [2023] conducted a systematic review of children's participation in game design, revealing that although PD and Co-design are widely used, there are still significant variations in how participation is implemented. Only half of the studies included children as true design partners. The authors suggest that the field would benefit from better documentation and justification for user involvement, as well as exploring factors that affect successful child participation, such as comprehension, cohesion, confidence, and accessibility.

Furthermore, the systematic review conducted by Ehsan *et al*. [2023] analyzed how engineering design was implemented with preschool children, highlighting the benefits of these activities in developing cognitive and technical skills. The authors suggest that while design practices provide valuable learning opportunities, there is still a lack of standardization in the methods used to assess the impact of these activities, making it difficult to compare results across different studies.

Despite providing relevant contributions to the field of design with children, the studies by Alhatem *et al*. [2019]; Saiger *et al*. [2023]; Ehsan *et al*. [2023] present limitations that still leave important gaps in the understanding of practices with young children. The study by Alhatem *et al*. [2019], for example, reviews participatory approaches, but generically treats children, without segmenting them by age group or analyzing the specificities of the early childhood education audience. The review by Saiger *et al*. [2023], although broad, focuses on applied games and includes mostly older children, neglecting the methodological challenges of including children between the ages of 4 and 6 in design processes. In turn, Ehsan *et al*. [2023] discuss the presence of children in design engineering practices, but with an emphasis on STEM education and without detailing participatory techniques or school contexts.

None of these studies discusses in depth the roles effectively assigned to children, the duration of interventions, or the role of the teacher as a mediator, elements that this systematic mapping sought to make explicit. By addressing these aspects in greater detail, this work contributes to filling methodological gaps and offering more applicable subsidies to the field of Co-design and PD in early childhood education.

4 Materials and Methods

This Systematic Mapping Study aimed to provide a rigorous and repeatable process for identifying and documenting scientific studies investigating collaborative design with preschool children. Our primary goal in performing this study was to investigate how Co-design and PD methodologies are used to involve children aged 4 to 6 in designing technological solutions. The mapping was mainly based on the guidelines defined by Petersen *et al*. [2008, 2015]. After identifying a set of relevant papers, we extracted the data needed to answer our research questions.

According to Petersen *et al*. [2008, 2015], a Systematic Mapping Study comprises five main steps: 1. Defining Research Questions, 2. Conducting the Search, 3. Screening of Studies, 4. Classification, and 5. Data Extraction.

In the *Defining Research Questions* step, we defined the research questions to guide our study, covering aspects such as the involvement of children in design processes and the methodologies employed. In the *Conducting the Search* step, we searched multiple digital databases to identify empirical studies involving preschool children (ages 4 to 6) in Co-design or PD processes. In the third step, *Screening of Studies*, we applied the inclusion and exclusion criteria to the retrieved studies. A total of 1217 studies were initially retrieved, with 34 studies ultimately selected for full analysis after applying the inclusion and exclusion criteria. In the fourth step, *Classification*, we categorized the selected studies based on the role of children in the design process and the types of techniques used. Finally, in the fifth step, *Data Extraction*, we extracted relevant data from the selected papers according to the predefined criteria.

The study was conducted by the two authors of the article. The first author is a Ph.D. student and conducted all the steps of the study. The second author is a professor with a Ph.D. in Computer Science and actively participated in the creation of the research protocol and reviewed the remaining steps. All the steps are detailed in the next subsections.

4.1 Research Question

The high-level research question of this study is: *How is the process of Co-design and PD carried out with preschool children?* Based on the main research question, we defined a set of two sub-questions and their motivations, summarized in Table 1. Each question covers a different facet of how the scientific literature has approached the design process, helping to outline a broad view of design with children and to structure our mapping results. Having such a comprehensive view is necessary to begin to look at design processes as a means of teaching computing concepts and providing environments that are more accessible and inclusive for such young children.

Table 1. Research Questions and motivations.

Research Question	Motivation
RQ1: How are Co-design and PD methodologies used with preschool children?	This research aims to understand how Co-design and PD methodologies are applied in the context of preschool children. The characteristics extracted are design techniques, research participants, children's ages, place of execution, and runtime.
RQ2: What is the role of children in the design process?	This research aims to understand the different ways in which children are integrated into the design process. In the context of Co-design and PD, it is essential to explore the roles played by children, whether they are informants, co-developers, or testers. The characteristics extracted are the design process steps.

4.1.1 Search Strategy

Two search strings were composed to identify all the possible articles that focused on collaborative design with preschool children (4 to 6 years). String 1 focused on children in the Co-design process, and String 2 focused on children in the PD process.

String 1: "(preschool OR "pre-school" OR kindergarten OR "early childhood") AND (codesign OR co-design)".

String 2: "(preschool OR "pre-school" OR kindergarten OR "early childhood") AND ("participatory design")".

Five electronic academic database searches were performed in ACM, IEEE, ScienceDirect, Scopus Elsevier, and Springer. The searches were restricted to include research articles published between 2015 and June 2025. The Strings syntax was adapted to accommodate different database search peculiarities. Regarding the Springer search tool, a filter was performed at the time of the research, in which only studies included in the following categories were accepted: "Conference Paper" and "Article". No other filters were applied to other databases or sources. Considering the two searches carried out, a total of 1217 studies were retrieved.

4.2 Inclusion and exclusion criteria

Articles were assessed against the inclusion and exclusion criteria presented in Table 2. For inclusion, articles had to be open-access. Articles that were not open-access were excluded. Articles not reporting on empirical research (e.g., theoretical works, systematic or scoping reviews), or articles not published in English, Portuguese, or Spanish were excluded.

Moreover, the definition of preschool varies from country to country, which is why only studies with children between the ages of 4 and 6 were considered. Some studies will present an age group different from that established. For example, studies investigating children aged 5-12 or 1-6 years will be presented. It should be noted that the first example concerns children aged 5-6 years, while the second example concerns children aged 4-6 years. For this mapping, to identify the characteristics of the knowledge base of collaborative design, the included articles had to use Co-design or PD with children aged between 4 and 6 years.

The study selection was conducted in two steps. In the first step, the titles and abstracts of each article were read. Then, the selection criteria were applied. When this preliminary reading was insufficient to obtain relevant information for research questions, the introduction and findings section of the study were read. In this study selection phase, 106 studies involving Co-design and 99 studies involving PD were accepted, totaling 205 articles selected for full reading. In the second step, full texts for the remaining articles were sought after the assessed relevancy of the full-text articles based on the inclusion and exclusion criteria. 205 full-text articles were assessed for inclusion; 171 were further excluded according to the exclusion criteria. In all, 34 articles were included in the review process.

Table 2. Inclusion and exclusion criteria

ID	Inclusion criteria	Exclusion criteria
1	The article focuses on children	The article focuses on children under 4 or over 6 years of age
2	The article is empirical research	The article is not open-access or paywalled
3	The article presents Co-design OR PD methods applied to children	The article was published before 2015
4		The article is not published in English, Portuguese, or Spanish

Figure 1 details the results and the reasons for exclusion at each stage of the review process, including identification, screening, and classification.

4.3 Data extraction

The following information was extracted from each article: (a) authors; (b) year of publication; (c) title; and (d) the country in which the study was conducted. Additionally, a classification scheme was developed to analyze other aspects related to each research study. The classification scheme is described below, as the categories used to classify the data.

- **Children age**: age range of children participating in the study.
- **Design technique**: techniques used during the design process, such as Co-creation, Comicboarding, Cooperative Inquiry, and others.
- **Children role**: using Druin's framework Druin [2002], children were classified as users, informants, testers, or design partners.
- **Research Participants**: the participant was classified according to their involvement in the research, such as child, teacher, researcher, parents, teacher, etc. When several participants took part in the research, they were grouped as: (researcher and child), (researcher, parents and child), (researcher, teacher and child), etc.
- **Place of execution**: the setting in which the study was conducted (school, university, research laboratory, etc.).
- **Runtime**: duration of design sessions with children. The

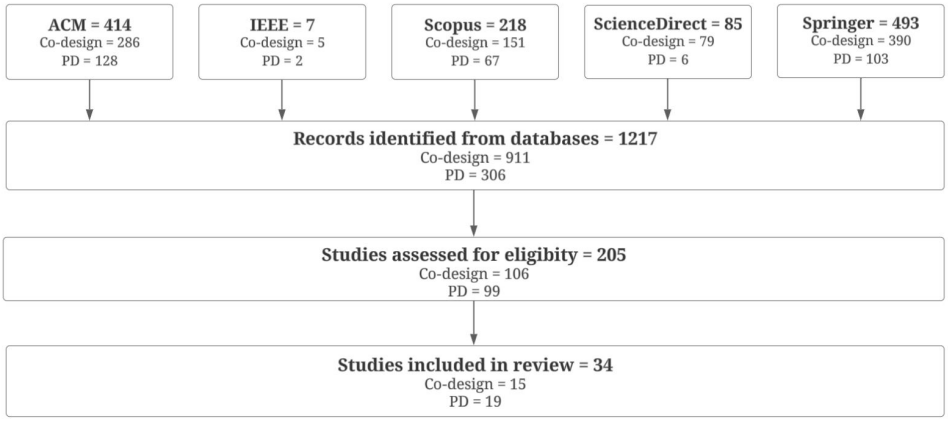


Figure 1. Flow diagram of included studies.

time was classified considering the number of meetings held or the duration, considering weeks and months.

Data was collected, analyzed, and categorized according to the classification scheme.

4.3.1 Threats to Validity

According to Petersen *et al*. [2015], threats such as descriptive validity, theoretical validity, interpretive validity, and repeatability can impact the quality of a study. Each of these threats and the measures taken to mitigate them are detailed below.

Descriptive validity is achieved when observations are described accurately and objectively [Petersen *et al*., 2015]. To reduce threats, a data extraction form was used to support data extraction.

Theoretical validity is determined by our ability to capture what we intended to capture [Petersen *et al*., 2015]. One potential threat is having only one person conducting the study selection, which can cause important studies to be missed. In this study, the inclusion and exclusion criteria were conducted by the first author. However, whenever there was any doubt regarding the classification, the second author was consulted, and a joint decision was made. Another threat can occur in the data extraction and classification process. The first author conducted the classification process to minimize this threat, but the second author reviewed the categories created.

Interpretive validity is achieved when the conclusions drawn are reasonable given the data and therefore map to the validity of the conclusion [Petersen *et al*., 2015]. A major threat in data interpretation is researcher bias, which was minimized by having a co-author review the study.

Repeatability requires a detailed account of the research process that is presented in this paper and follows existing guidelines [Petersen *et al*., 2015]. In this research, we took steps to maximize repeatability, such as well-defined inclusion and exclusion criteria, a list of criteria used for exclusion, and the data extraction form.

A snowballing sampling process was not performed, nor was a manual search included, due to the number of studies found (29 in total). We believe that the total number of studies provides us with an overview of the literature. However, this may be a limitation of this study. Furthermore, the exclusion of articles with restricted access may have led to coverage bias.

Another limitation concerns the databases used. Even though the ACM, IEEE, Springer, ScienceDirect, and Scopus databases returned 1217 papers to filter and analyze, which we considered a reasonable number of areas, we left important databases out of our protocol, such as SOL and the Brazilian Computer Society's library. We believe that future systematic mappings should include these databases to encompass the Brazilian context in this research area.

5 Results

From the initial 1217 studies, 34 were selected according to the selection criteria, which represents 3.11% of the retrieved papers. The full list of selected papers, including title and author name, is present in the Appendix, Tables 10 and 11.

The combined characteristics of the 34 articles included in this review are provided in this section. The characteristics were divided considering which methods were used in the study. Table 3 provides details of all articles included in this review.

In summary, Co-design studies were conducted in the United States (40%), Italy (13,3%), Denmark (6,6%), China (6,6%), Korea (6,6%), Romania (6,6%), Spain (6,6%), United Kingdom (6,6%), and Sweden (6,6%). PD studies were conducted in Australia (15,7%), Greece (15,7%), the United States (15,7%), China (10,5%), Finland (10,5%), Brazil (10,5%), Germany (5,2%), Romania (5,2%), and Sweden (5,2%). One PD study was conducted across Costa Rica and Brazil. It is possible to notice an increase in the number of studies over the years (in both methods), this growth decreases considerably during the COVID-19 pandemic between 2020 and 2021 and grows again in 2024. Therefore, the field of study relating collaborative design methodologies to preschool children still needs to be explored, regardless of the method used.

Figure 2 summarizes the results of the research question, presenting the main categories created for each extracted data item. The number in parentheses indicates the number of articles related to the respective category, without considering methods.

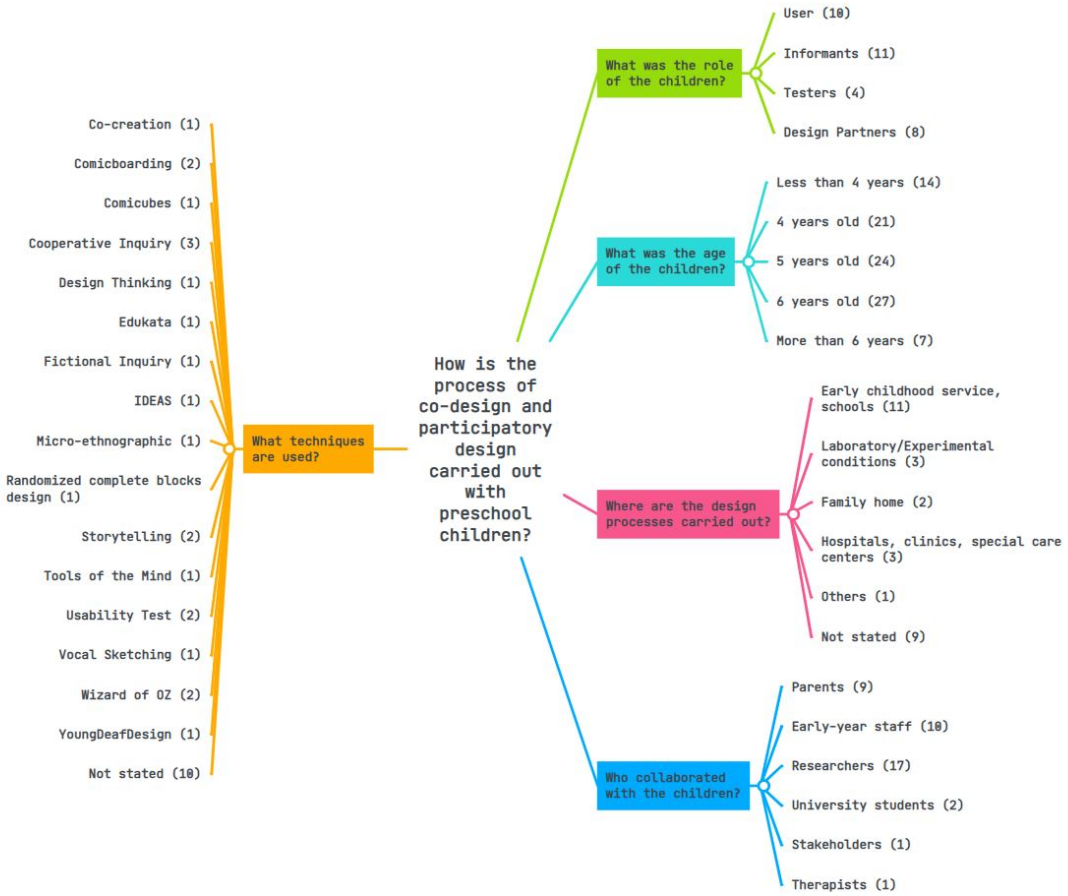


Figure 2. Overview of Research Questions.

Table 3. Combined details of articles included in this review.

Details	Number of Co-design articles	Number of PD articles
Year of publication		
2015		2 (10,5%)
2016		2 (10,5%)
2017	3 (20%)	5 (26,3%)
2018	2 (13,3%)	1 (5,2%)
2019	2 (13,3%)	1 (5,2%)
2020	3 (20%)	5 (26,3%)
2022	1 (6,6%)	1 (5,2%)
2023	1 (6,6%)	
2024	3 (20%)	2 (10,5%)
Country (of study)		
United States	6 (40%)	3 (15,7%)
China	1 (6,6%)	2 (10,5%)
Romania	1 (6,6%)	1 (5,2%)
Sweden	1 (6,6%)	1 (5,2%)
Denmark	1 (6,6%)	
Italy	2 (13,3%)	
Korea	1 (6,6%)	
Spain	1 (6,6%)	
United Kingdom	1 (6,6%)	
Australia		3 (15,7%)
Greece		3 (15,7%)
Finland		2 (10,5%)
Brazil		2 (10,5%)
Germany		1 (5,2%)
Costa Rica and Brazil		1 (5,2%)

Table 4. Participants of articles included in this review.

Participant group	Number of Co-design articles	Number of PD articles
Children	12 (100%)	17 (100%)
Parents	7 (58,3%)	2 (11,8%)
Early-year staff	6 (50%)	4 (23,5%)
Researchers	4 (33,3%)	13 (70,5%)
University students	1 (8,3%)	1 (5,9%)
Stakeholders		1 (5,9%)
Therapists		1 (5,9%)

5.1 Answering the Research Questions

In the following, we answer each of the research questions.

RQ1: How are Co-design and PD methodologies used with preschool children?

All the studies involved children (15 Co-design and 19 PD studies). However, as we can see in Table 4, other participants are involved in the research, such as parents (8 Co-design and 3 PD studies), early years staff (7 Co-design and 6 PD studies), university students (2 Co-design and 1 PD studies), stakeholders (1 Co-design and 1 PD study), and health professionals (1 Co-design). In several studies, the researchers actively participated in the design process (5 Co-design and 16 PD studies). In these cases, the researcher was responsible for conducting activities with the participants and was responsible for leading the design process.“Early childhood staff” includes early childhood education teachers, pedagogues, service directors, and possible actors who are part of early childhood education.

Among this wide variety of participants, we can see different groups working together, such as “children and parents”,

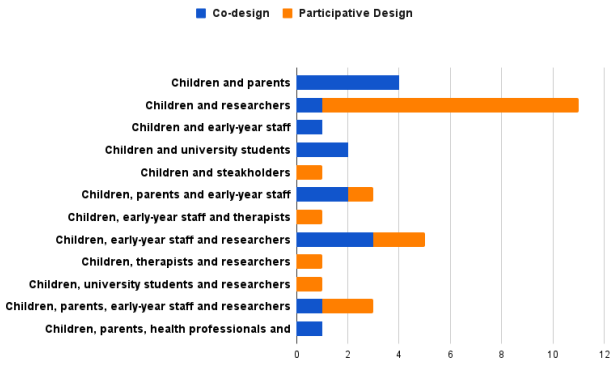


Figure 3. Group of participants.

"children, parents and Early-year staff", and "children, therapists and researchers", for example. Figure 3 presents all the different groups of participants identified in the studies. It is observed that PD is predominantly employed in interactions between children and researchers (10 studies), while Co-design is widely used in contexts involving children and multiple groups, such as parents, Early-year staff, and researchers. In addition, Co-design also stands out for the diversity of participating groups, including children, university students, and other stakeholders, reinforcing its collaborative and inclusive character. On the other hand, PD presents a more focused application, especially in contexts where researchers have a greater influence on the design process. These results suggest that Co-design is more frequently used in scenarios that require collective creativity and integration of multiple perspectives, while PD is better suited to processes with a more directive and hierarchical focus.

All studies involved children aged 4 to 6 years. However, several ages were mapped. Some studies include children under four years old or over 6. Examples in this area are studies that involve children between 4-11 years old in their design process (ID-1) or studies that include children from 2-6 years old (ID-15).

Specifically, 25 studies included 4-year-old children, 29 studies worked with 5-year-old children, and 22 with 6-year-old children. Some studies also incorporated children outside this age range; 17 studies included children under 4 years old, and 8 studies included children over 6 years old, indicating an age diversity in the processes analyzed.

Most studies involved children between 4 and 5 years old, while children under 4 or over 7 years old appeared less frequently. This age concentration may be related both to the literature in the area, which traditionally explores involvement in early childhood, and to practical factors, such as children's communication skills and expectations of inclusion in structured design processes. Older children, on the other hand, tend to be included in studies focused on formal computer or robotics education, which may explain their lower presence in this mapping focused on early childhood.

Table 5 presents the studies classified considering the age goal of the research. In this case, a study with 3 to 6-year-old children will be counted four times in the classification (less than 4, 4, 5, and 6 years), for example.

The settings where design processes were conducted included a wide range of contexts. Data were predominantly collected from formal education settings such as early childhood services and schools (3 Co-design and 11 PD studies). These include, for example, primary schools, elementary schools, preschools, kindergartens, and daycare centers. Another location option that appeared was laboratories with experimental conditions, including university-based laboratories and workshops (2 Co-design and 2 PD studies). Furthermore, in Co-design studies, 2 (13,3%) studies captured data from families' homes during the pandemic, and 1 (6,6%) study from other public spaces such as museums. In PD studies, 3 (15,7%) studies captured data from hospitals and special care centers. Finally, a large number of studies did not state the setting of the study (7 Co-design and 3 PD studies). Table 6 shows this classification.

Table 5. Children's age in articles included in this review.

Ages	Number of Co-design articles	Number of PD articles
Less than 4 years	9	8
4 years old	14	11
5 years old	13	16
6 years old	6	14
More than 6 years	2	6

Table 6. Classification of included articles according to the place of execution.

Setting (of study)	Number of Co-design articles	Number of PD articles
Early childhood service, schools	3 (20%)	11 (57,8%)
Laboratory/Experimental conditions	2 (13,3%)	2 (10,5%)
Family home (including through telephone/Skype/Zoom)	2 (13,3%)	
Others (e.g., public spaces including museums)	1 (6,6%)	
Hospitals, clinics, special care centers		3 (15,7%)
Not stated	7 (46,6%)	3 (15,7%)

In most studies, the activities took place in school contexts, which reveals a predominance of the use of Co-design and PD as a strategy to support teaching and learning processes. Projects carried out in schools tend to focus on the development of cognitive, motor, and social skills, while those carried out in laboratories or museums (ID-2, ID-4) sought to test technologies under development or expand children's creative expression. The prevalence of the school context may be associated with the ease of access to groups of children, the curricular integration with pedagogical activities, and the educational potential of the artifacts developed.

Without considering methods, studies had different durations, ranging from 1 session to 3 years. The classification mainly considered the number of meetings held. Studies classified as unique sections could include 30-minute to 3-hour meetings. Studies with durations in weeks, months, and years did not provide the number of meetings that were held in this period. Table 7 shows this classification.

The studies analyzed varied greatly in duration, ranging from one-off activities of 1 or 2 sessions (ID-1, ID-6, ID-15, ID-24, ID-26) to longitudinal projects with more than 25 sessions or that lasted for months or even years (ID-22, ID-27, ID-30, ID-33). Short-term studies were generally related to

Table 7. Design process duration in articles included in this review.

Ages	Number of Co-design articles	Number of PD articles
1 section	1	3
2 sections	2	
3 sections	1	1
4 sections	1	1
6 sections		1
10 sections		1
12 sections	1	
15 sections	1	1
2 weeks		1
3 weeks	1	
2 months		1
3 months	1	1
4 months	1	1
3 years		1
Not stated	4	7

exploratory proposals, concept testing, or immediate feedback collection. Long-term studies were often associated with school contexts with ongoing weekly meetings and involved greater engagement of children in multiple stages of the design process. This difference appears to be related to the type of institution involved (e.g., school vs. research laboratory), the degree of maturity of the project, and the methodological proposal adopted. 4 Co-design studies and 7 PD studies did not state the process duration. There is no consensus or homogeneity about the duration of design processes carried out with preschool children.

To understand how these collaborative design processes were conducted, it is important to know what techniques are used in the process. We identified 17 distinct approaches. All the techniques reported in the 34 studies will be listed and described objectively. They were presented alphabetically and referenced with the study ID in which they were used.

- **Co-creation:** it's a collaborative development of new value (concepts, solutions, products, and services) together with experts and/or stakeholders (such as customers, suppliers, etc.). Co-creation is a form of collaborative innovation: ideas are shared and improved together, rather than kept to oneself [Sanders and Stappers, 2008] (ID-1).
- **Comicboarding:** is a requirements elicitation technique that uses comics with partially completed content to scaffold children's storytelling and ideation. It leverages familiar narrative formats to reduce cognitive load and support expression of design ideas [Moraveji *et al*., 2007] (ID-3, ID-20).
- **Comicubes:** is a tangible physical object that allows for three-dimensional manipulation. The tool affords various forms of interaction, depending on its users' age and skills. Comicubes combine ideas associated with toys, games, and comic-style storytelling [Heljakka and Ihamäki, 2016] (ID-24).
- **Cooperative Inquiry:** also known as collaborative inquiry, is a participatory design approach that proposes involving children as partners in the design process, working side by side with adults (researchers, designers, developers) during all phases of technological development [Druin, 1999] (ID-1, ID-20, ID-32).
- **Design Thinking**: is a methodology that imbues the full spectrum of innovation activities with a human-centered design ethos. It is a way of finding human needs and creating new solutions using the tools and mindsets of design practitioners [Brown *et al*., 2008] (ID-14, ID-19).
- **Edukata Design Model:** includes several workshops with stakeholders that iteratively progress with reflection sessions. The activity aims to reach set goals and outputs. The PD sessions in Edukata enhance participants' understanding of the design context, challenges, and opportunities, guiding them to achieve concrete results [Toikkanen *et al*., 2015] (ID-34).
- **Fictional Inquiry:** is a design method in which designers and users collaborate within a shared fictional world. By creating a fictional context and inviting participants to adopt roles within it, the method allows for exploration of design ideas and issues beyond the constraints of current reality [Dindler and Iversen, 2007] (ID-3).
- **Interface Design Experience for the Autism Spectrum (IDEAS):** is a participatory design methodology developed specifically to support children with Autism Spectrum Conditions (ASC) within co-design activities. It includes strategies to scaffold participation, such as familiarization with people and spaces, consistent routines, and adapted communication methods [Benton *et al*., 2012] (ID-16).
- **Micro-ethnographic Explorations:** the ethnographer, photographer, and videographer record particular images or events. In turn, it makes visible the social patterns, practices, and norms of their group [Smith, 1978] (ID-27).
- **Randomized Complete Block Design**: is an experimental design in which experimental units are grouped into blocks, and treatments are randomly assigned within each block. Each treatment appears once in every block [Kuehl, 2000] (ID-2).
- **Storytelling:** it consists of engaging in meaning-making and world-building, constructing identities and negotiating social roles through the act of telling stories [Nicolopoulou, 2013] (ID-13, ID-15).
- **Usability Test**: a technique used to evaluate a product by testing it on users, to identify usability problems, collecting qualitative and quantitative data, and determining the participant's satisfaction with the product [Nielsen, 1994] (ID-17, ID-22).
- **Tools of the Mind:** an early childhood curriculum and teaching approach grounded in Vygotskian theory, emphasizing the development of cognitive and self-regulation skills through structured make-believe play, private speech, and scaffolding [Bodrova and Leong, 2024] (ID-11).
- **Vocal Sketching:** is the act of using one's voice to produce a representation or prototype of a sound-related design idea. This method aims to support ideation and communication during participatory design sessions focused on auditory features [Falkenberg *et al*., 2020] (ID-4).
- **Wizard of OZ**: this is a process in which a user interacts with an interface without knowing that the responses are being generated by a human, not a computer [Dahlbäck *et al*., 1993] (ID-5, ID-12).
- **YoungDeafDesign Design Method**: is a method that consists of four phases to design with young deaf chil-

dren: Sensitization, Design Sessions, Clustering and Analysis, and Final Concept Design. It emphasizes multimodal, visual, and embodied interactions to accommodate children's communication preferences and to support inclusive design processes [Brinck *et al*., 2022] (ID-33).

- **Not stated:** when the method used for the design process is not mentioned by the author (ID6, ID-7, ID-8, ID-9, ID-10, ID-18, ID-21, ID-23, ID-25, ID-26, ID-28, ID-29, ID-30, ID-31).

Table 8. Techniques used in articles included in this review.

Techniques	Number of Co-design articles	Number of PD articles
Co-creation	1	
Comicboarding	1	1
Comicubes		1
Cooperative Inquiry	1	2
Design Thinking	1	1
Edukata		1
Fictional Inquiry	1	
IDEAS		1
Micro-ethnographic exploration		1
Randomized complete blocks design	1	
Storytelling	2	
Tools of the Mind	1	
Usability Test		2
Vocal Sketching	1	
Wizard of OZ	2	
YoungDeafDesign		1
Not stated	5	9

Table 8 shows all mapped techniques divided by the number of occurrences in which method. Usability testing is not a design method but an interface evaluation method. However, in these cases, children participated as testers of ready-made solutions.

Several studies have not stated which techniques were used. In PD studies, this case represents 47,3% of all PD studies recovered. In Co-design studies, this represents 33,3%. Furthermore, we noticed that only Comicboarding and Cooperative Inquiry were used in both approaches.

Some techniques were used together. Examples in this area included studies where (a) Comicbording and Fictional Inquiry were used in a workshop to generate ideas for implementing a system to help children plan how to spend their free time with media (ID-3); (b) Cooperative Inquiry and Co-creation were used to engage children in an inclusive letter-writing app design (ID-1); and (c) Cooperative Inquiry and Comicboarding were used to design a mobile game to help preschoolers learn Chinese characters (ID-20).

It is important to highlight that, among the techniques identified in this mapping, two were proposed in the studies analyzed: YoungDeafDesign (ID-33) and Vocal Sketching (ID-4). These approaches are not based on previously consolidated methods. Still, they are described as original creations developed specifically to meet the needs of certain groups of children in participatory design contexts (deaf children and young children involved in sound interaction design processes). The presence of original methods in the primary studies represents a significant contribution to the area, evidencing a movement of adaptation and methodological innovation aimed at inclusion and expanding forms of child participation.

Regarding the products developed, the highlights were paper prototypes (ID-2, ID-5, ID-6, ID-20, ID-25, ID-32), simple digital interfaces (ID-12, ID-19, ID-23), physical materials such as musical instruments (ID-4), 3D tactile materials (ID-15), 3D cubes, (ID-24), and multimodal materials such as texts, draws, videos, and audios (ID-7, ID-26, ID-27, ID-34). In some cases, the products were the result of single ideation sessions; in others, they were developed over several weeks of activities. These creations not only formed the final artifacts of the projects but also served as tools of expression for the children.

RQ2: What is the role of children in the design process?

Children's roles in the design process were categorized based on Druin's framework [Druin, 2002], which identifies children as users, testers, informants, or design partners. This can help to understand the children's role in the design process.

- **Users**: Children are considered the final recipients of the technology, with their involvement limited to interacting with completed designs. In this role, the focus is primarily on observing how children use the product to identify issues or opportunities for improvement. Usability testing and observational studies are commonly employed methods at this stage, where children's input is indirect and occurs after design.
- **Informants**: Children serve as valuable sources of insight during specific phases of the design process, such as ideation or prototype evaluation. Designers rely on interviews, observations, and discussions to understand children's needs, behaviors, and preferences, which inform the design decisions. However, their involvement is periodic and situational rather than continuous.
- **Testers**: children engage with early or intermediate versions of the technology, providing direct feedback on functionality and user experience. This role represents an iterative approach, where children's responses are utilized to refine the design incrementally. While children contribute actively through feedback, their influence on the conceptualization and decision-making aspects of design remains minimal.
- **Design Partners**: Children become integral contributors throughout the entire design process. As partners, they work alongside designers, participating in brainstorming sessions, decision-making, and the iterative refinement of ideas. This role embodies the principles of Co-design and PD, emphasizing shared ownership and mutual learning between children and adults. It also reflects a methodological shift, requiring designers to adapt processes to accommodate children's active and meaningful participation.

The categorization of children's roles was based on Druin [2002] taxonomy, as it is the most consolidated approach in the literature and allows comparison with previous studies. However, we recognize, as argued by de Morais *et al*. [2024], that this classification may not capture all the nuances of children's participation, especially in school contexts less structured for participatory practices. These authors propose the recognition of intermediate roles, which move between

classic categories and reflect more situated forms of children's involvement. Although we have maintained Druin's classification in this study, we consider these contributions relevant.

Table 9 shows the children's roles in the design process. In some Co-design studies, children had more than one role in the design. In the PD studies, children had a single role.

Table 9. Children's roles in articles included in this review.

Role	Number of Co-design articles	Number of PD articles
Users	5	5
Informants	8	4
Testers	3	3
Design Partners	4	7

In the Co-design studies, most children were included as users or informants. 5 studies included children as users (ID-2, ID-9, ID-10, ID-12, and ID-13) and 8 as informants (ID-1, ID-8, ID-10, ID-11, ID-12, ID-13, ID-14, ID-15). Only 4 studies included children as design partners (ID-3, ID-4, ID-6, ID-7), which represents a small number in this role, as children have significant input into all phases of design. In PD studies, 5 studies included children as users (ID-16, ID-17, ID-22, ID-28, ID-33), 4 as informants (ID-20, ID-27, ID-29, ID-32), and 7 as design partners (ID-21, ID-23, ID-24, ID-25, ID-26, ID-30, ID-34). Here we can see more studies including children in the role that most contributes to their learning. The role of testers was the least used, with 3 studies in each method (ID-1, ID-5, ID-8, ID-19, ID-20, ID-31).

In all PD studies, children had a single role during design. In contrast, in Co-design studies, we can observe children with more than one role, such as informants and users (ID-10, ID-11, ID-13) or informants and testers (ID-1, ID-8).

In the studies involving children as informants (ID-10, ID-27, ID-29, ID-32), children were consulted about preferences, themes, and visual elements, usually in the middle or final stages of the project. When they acted as users (ID-9, ID-16, ID-17, ID-22, ID-28), children participated in the activities only as end users, interacting with games, virtual agents, or interfaces that had already been developed. Their actions were observed for validation or usability evaluation purposes, without direct involvement in creative or conceptual decisions. While this type of participation is still valid in the context of child-centered design, it limits the opportunities for active listening and agency on the part of children in the design process.

The role of design partners appeared in smaller numbers, but with more expressive contributions. In ID-24, for example, children participated from the definition of the problem to the creation of physical and digital solutions, including the assembly of narrative cubes and the dramatization of situations. In the ID-3 study, children were involved in recurring co-investigation and design sessions, acting in all phases: ideation, development, and validation of prototypes. In these cases, they were able to directly influence decisions about the aesthetics, narrative, and functionality of the products created.

Furthermore, combined roles were found, such as "user and informant" (ID-11, ID-12, ID-13) or "informant and tester" (ID-1, ID-8), indicating that, in some cases, the child's involvement was progressive or multifaceted. This variation shows that practice does not always fit neatly into classic models of participation, suggesting the need for more flexible and context-sensitive categories.

In some cases, children aged 4 and under had a little more difficulty being included in the design process. The authors point out that 4-year-old participants responded to the requests creatively, but with completely off-topic comments (ID-3), had difficulty creating paper prototypes that related to what was requested (ID-20), and in some cases, the children did not always present enough information in their designs (ID-4). Another point raised would be the anxiety that caused the children to be unable to pay attention to the instructions (ID-31).

6 Discussion

This section critically analyzes the main findings of the mapping, focusing on the aspects that favored or limited the participation of children aged 4 to 6 in Co-design and PD processes. Based on the studies analyzed, good practices observed, difficulties faced, and recommendations that emerge from the practice with this specific audience are discussed.

A recurring and successful practice was the use of concrete materials and narrative techniques, especially for children aged 5 to 6. For example, studies that applied Comicboarding and the use of physical cubes reported that these resources facilitated the communication of ideas, even by children with little verbal fluency. Children are actively engaged when manipulating blocks, assembling stories with images, or drawing on interactive surfaces. Techniques such as Storytelling and Edukata were also associated with a greater ability of children to imagine and prototype solutions collaboratively, as observed in projects that resulted in prototypes of games, instruments, and multimodal narratives (texts, photos, audios, and videos).

These findings can be further understood through the lens of embodied cognition, which proposes that cognitive processes are grounded in bodily action and sensorimotor interaction with the environment [Wilson, 2002; Thelen, 2000]. The effectiveness of techniques based on tangible manipulation, gesture, and physical exploration aligns with evidence indicating that young children often "think through doing," with cognition tightly linked to action and movement. This perspective suggests that the success of tangible and narrative-based design activities is theoretically expected and reinforces the need for methods that integrate materiality and embodied interaction into early childhood design processes [Glenberg, 2010; Dourish, 2001].

Short, iterative, and well-organized sessions were more effective. Studies that held weekly meetings lasting between 30 and 60 minutes, allowing time for adaptation, reported greater comfort and involvement among children. The presence of adults with a facilitating attitude was also a differential. In school contexts where teachers were prepared to act as mediators of the process, greater fluidity in exchanges and greater autonomy among children in proposing and reviewing ideas were observed, as in projects that used the Cooperative Inquiry methodology.

From a Vygotskian perspective, this facilitator role can be interpreted as a form of scaffolding, temporary support strategies that help children accomplish tasks they would not be able to complete independently [Vygotsky, 1978; Wood *et al*., 1976]. Such mediation, which may include modeling actions, reframing questions, or co-constructing prototypes, aligns with the Zone of Proximal Development, in which learning progresses through guided participation. This framing helps explain why sessions with well-prepared adults or teachers produced richer contributions and more sustained engagement, particularly among younger children whose executive function and self-regulation are still developing [Carlson, 2016].

The mapping identified a variety of products created by children, from paper prototypes and digital interfaces to videos, illustrated stories, and physical games. Children participated in the creation of artifacts that reflected their ideas about technology, everyday life, and play. In one project, for example, they created a prototype for an AI voice agent that guided children through the toilet [Huh *et al*., 2022], and in another, they composed a Child Orchestra using co-designed musical instruments [Core *et al*., 2017]. These results show that, even at an early age, children can contribute significantly and materially to the design process when the context is favorable.

This collaborative artifact creation also resonates with socio-constructivist theories, which emphasize that knowledge is co-constructed through social interaction and shared meaning-making [Rogoff, 2003]. Many co-design activities in the studies, such as group prototyping, collaborative storytelling, or negotiated decision-making, functioned as social learning processes. Peer interaction, dialogue, and joint problem-solving, long recognized as cognitively valuable [Forman and Cazden, 2013], appear to play a central role in enabling children to articulate and refine design ideas. Thus, the social nature of many design sessions is not only methodologically relevant but theoretically significant.

One of the most notable challenges was the lack of a detailed methodological description. In 14 studies, the techniques used were not specified or were described in a generic way, which makes critical evaluation and replication of successful experiences difficult. Furthermore, few studies reported how the sessions were structured, how the adults were mediated, or how the children's ideas were documented. This methodological opacity represents a barrier to the consolidation of good practices in the area.

The categorization of children's roles revealed a predominance of passive participation. Most studies classified children as users or informants, with only 11 considering them as design partners. This tendency often reflects structural limitations, such as the organization of schools, teacher training, or the research model adopted. Even when children participated in creative sessions, they did not always influence design decisions. There was also an underrepresentation of children under 5 years old, which points to a possible age bias in the selection of participants.

Interpreting these patterns through theoretical perspectives helps clarify why they matter. Participation roles that restrict children to users or informants limit opportunities for scaffolding, embodied exploration, and social co-construction of meaning, mechanisms known to support early learning and development [Vygotsky, 1978; Glenberg, 2010]. Conversely, studies that engaged children as design partners tended to align more closely with principles of socio-constructivism and guided participation, providing conditions for agency, creativity, and deeper involvement in the design process.

Based on the analysis of the 34 studies, some lessons for the practice of collaborative design with young children stand out: (I) Methods based on visual narrative and physical manipulation (e.g., Comicboarding, Storytelling, blocks) proved to be more effective for children aged 5–6; (II) The structure of the sessions (short, iterative, and continuous) favored engagement and reduced dispersion; (III) The role of the adult facilitator needs to be better described and valued, as it is central to ensuring children's protagonism; (IV) Studies that allowed children to see their products take concrete form reported greater motivation and a sense of belonging to the process; and (V) There is a lack of systematic studies with children aged 3 and 4, which represents a relevant gap to be explored.

Integrating these insights with established theories suggests that approaches deliberately incorporating scaffolding [Vygotsky, 1978], embodied interaction [Wilson, 2002], and collaborative meaning-making [Rogoff, 2003] may be particularly effective in supporting meaningful participation in early childhood design contexts. Future research can benefit from grounding methodological choices in these theoretical perspectives, enhancing both rigor and explanatory power.

7 Conclusion

This systematic mapping analyzed 34 studies involving children aged 4 to 6 in Co-design and PD processes. The most commonly used techniques included visual narratives, physical objects, and mediated sessions in school contexts. Most children were included as informants or users, and only a third of the studies considered children as design partners.

The results reveal good practices, such as the use of playful materials, structured sessions, and active mediation, but they also point to persistent challenges, such as the lack of methodological clarity, the predominance of passive participation, and the low inclusion of younger children. The scarcity of studies detailing the role of the teacher or the pedagogical impact of activities also limits the field's advancement.

Studies such as Heljakka and Ihamäki [2017], Core *et al*. [2017], and Hiniker *et al*. [2017] have shown that techniques that combine visual expression, tangible prototyping, and continuity favor meaningful participation of young children. Such approaches should be explored further, especially with children aged 4 to 5, who are still underrepresented.

When interpreting these results through theoretical frameworks of development, such as socio-constructivism and Vygotsky's theory of mediation, it becomes evident that children's participation in design depends not only on techniques, but also on the creation of supportive contexts that enhance expression, collaboration, and embodied reasoning characteristic of this age group. This theoretical articulation allows us to understand why narrative, embodied, and mediated approaches tend to generate richer design experiences that are more aligned with the ways in which young children construct

knowledge about the world.

In addition to clarifying the prevalence of Druin's traditional roles, our mapping revealed the emergence of several "intermediate" or hybrid participation roles that did not fit neatly into existing taxonomies. Across the studies, children often moved fluidly between informing, testing, and collaboratively shaping ideas within the same design process, assuming levels of agency that fluctuated according to task structure, adult mediation, and material affordances. These patterns resonate with the argument of de Morais *et al*. [2024] that children's participation in early childhood settings is often situated, negotiated, and context-dependent rather than fixed within predefined categories. Recognizing these hybrid forms of participation, such as children who begin as informants but progressively co-create prototypes, or those who test solutions while simultaneously suggesting design modifications, strengthens the theoretical contribution of our work by emphasizing the need for more flexible, context-sensitive frameworks that capture the nuances of participation in early childhood Co-design and PD.

It is recommended that future research more systematically document the techniques used, the role of adults in the mediation process, and the concrete products developed by children. The creation of more robust methodological reporting protocols can contribute to the replication of good practices. In addition, it is necessary to advance in the construction of participation models that are more context-sensitive, which consider aspects such as children's adaptation time, teacher training, and school culture. It is also important that studies include a greater diversity of age groups, especially children aged 3 and 4, and explore new participation roles, going beyond the traditional taxonomy of Druin [2002]. The investigation of intermediary roles, as discussed by de Morais *et al*. [2024], can reveal important nuances in how children effectively contribute to design processes. Finally, we suggest that future research also examine the impacts of these participatory experiences on the development of creativity, critical thinking, and children's protagonism, contributing to a more integrated dialogue between participatory design and pedagogical objectives of early childhood education.

Declarations

Authors' Contributions

SR and VN contributed to the conception of this study, analysis, and writing. SR is the main contributor and writer of this manuscript. VN participated in the validation of the study, review, and final editing. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

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Availability of data and materials

The datasets generated and analysed during the current study will be made available upon request.

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A Appendix

Table 10. Reviewed Co-design papers and identification numbers.

ID	Title	Authors
	CO-DESIGN	
ID-1	Child-centered design developing an inclusive letter writing app	Martens *et al*. [2018]
ID-2	Coco's video: An empirical investigation of video-player design features and children's media use	Hiniker *et al*. [2018]
ID-3	Co-design with preschoolers using fictional inquiry and comicboarding	Hiniker *et al*. [2017]
ID-4	Creating digital music instruments with and for children: Including vocal sketching as a method for engaging in codesign	Falkenberg *et al*. [2020]
ID-5	Designing a music playground in the kindergarten	Core *et al*. [2017]
ID-6	Designing Collaborative ScratchJr for Multi-touch Tabletops	Barragán *et al*. [2024]
ID-7	Enabling participation in community-dwelling children and young people with acquired brain injuries and their families: a theory-based, evidence-based and person-based approach to intervention development	Keetley *et al*. [2024]
ID-8	Integrating Fundamental Movement Skills and Mathematics in Early Childhood: A Pilot Study	Capio *et al*. [2024]
ID-9	Junkbox: A waste management educational game for preschool kids	Gizzi *et al*. [2019]
ID-10	Play to learn! Nurturing fundamental digital skills of Romanian preschoolers by developing edutainment applications	Guran *et al*. [2020]
ID-11	Play-Based Design: Giving 3- to 4-Year-Old Children a Voice in the Design Process	Superti Pantoja *et al*. [2020]
ID-12	Service design of artificial intelligence voice agents as a guideline for assisting independent toilet training of preschool children	Huh *et al*. [2022]
ID-13	The dimensions of reflection coding scheme: A new tool for measuring the impact of designing for reflection in early childhood	Hubbard *et al*. [2023]
ID-14	The SEL transition wheel: Designing for early childhood social-emotional learning	Stangl *et al*. [2017]
ID-15	Towards a child-led design process A pilot study: when pre-schoolers play becomes designing	Södergren and van Mechelen [2019]

Table 11. Reviewed PD papers and identification numbers.

ID	Title	Authors
	PARTICIPATORY DESIGN	
ID-16	A Participatory Approach for Game Design to Support the Learning and Communication of Autistic Children	Porcino *et al*. [2015]
ID-17	A Universe Inside the MRI Scanner: An In-Bore Virtual Reality Game for Children to Reduce Anxiety and Stress	Liszio *et al*. [2020]
ID-18	Applying UCD for Designing Learning Experiences for Romanian Preschoolers. A Case Study	Adriana-Mihaela *et al*. [2019]
ID-19	ArticuMotion: Towards Assessing Motor Speech Disorders via Gamification	Alsebayel *et al*. [2024]
ID-20	Chinese Preschoolers as Design Partners – Lessons Learned	Liu and Roto [2017]
ID-21	Designing a Virtual Reality Empathy Game Framework to Create Empathic Experiences for Children	Muravevskaia and Gardner-McCune [2023]
ID-22	Designing Tools that Allows Children in the Early Childhood to Program Robots	Ramírez-Benavides *et al*. [2017]
ID-23	Developing kindergarten students' game design skills by teaching game design through organized game design interventions	Kalmpourtzis [2019]
ID-24	Digital Natives and Cardboard Cubes: Co-Creating a Physical Play(ful) Ideation Tool with Preschool Children	Heljakka and Ihamäki [2017]
ID-25	Educational Game for Laterality Development in Early Childhood and the Importance of Participatory Design	Cavedini *et al*. [2020]
ID-26	GIS-based intelligent planning approach of child-friendly pedestrian pathway to promote a child□friendly city	Fang *et al*. [2024]
ID-27	Images of Play Experiences Through a Child's Lens: An Exploration of Play and Digital Media with Young Children	Eckhoff [2017]
ID-28	MyCalendar: Fostering Communication for Children with Autism Spectrum Disorder Through Photos and Videos	Abdullah and Brereton [2015]
ID-29	Rationale, Design and Methods Protocol for Participatory Design of an Online Tool to Support Industry Service Provision Regarding Digital Technology Use 'with, by and for' Young Children	Edwards *et al*. [2020]
ID-30	Teaching game design to students of the early childhood through Forest Maths	Kalmpourtzis *et al*. [2016]
ID-31	The child's perspective as a guiding principle: Young children as co-designers in the design of an interactive application meant to facilitate participation in healthcare	Stålberg *et al*. [2016]
ID-32	The role of early childhood students in the design of digital and physical games	Kalmpourtzis *et al*. [2018]
ID-33	YoungDeafDesign: A Method for Designing with Young Deaf Children	Korte *et al*. [2017]
ID-34	Zones of participation – a framework to analyze design roles in early childhood education and care (ECEC)	Brinck *et al*. [2022]