Social Play Between Deaf and Hard of Hearing Children and Hearing Peers: Learning from Children and School Ecosystems

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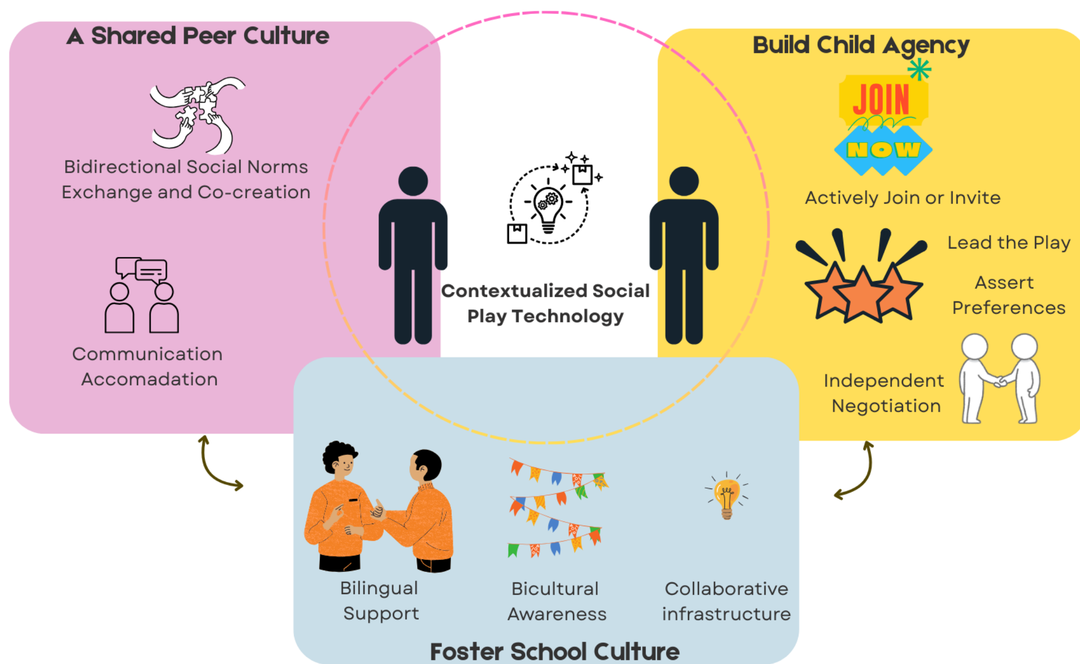

Figure 1: Contextualized Social Play Technology. Social play technology design space for DHH and hearing children on school playgrounds. Based on three levels: school culture, peer culture, and personal agency

Abstract

Social play is an essential pathway for emotional, cognitive, and social development in children. However, Deaf and Hard of Hearing (DHH) children often experience barriers to social play, namely in mixed-hearing ability environments (e.g., school playground). In

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CHI '26, Barcelona, Spain
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ACM ISBN 979-8-4007-2278-3/26/04
https://doi.org/10.1145/3772318.3791520

this paper, we conducted interviews with six educators and 19 children with and without hearing loss at a Partially Bilingual School, to better understand their experiences during social play. Moreover, we observed a school playground with 46 children over seven weeks at a Full Bilingual School. Findings show that social play between DHH and hearing children is influenced by school culture, peer culture, and child agency. Importantly, some of these barriers can be (partially) overcome through a supportive bilingual and bicultural environment. We propose the concept of contextualized social play technology, which defines a design space aimed at fostering peer culture and individual agency through contextualization within schools. We also provide design insights to inform the development of future inclusive play technologies.

CCS Concepts

• **Human-centered computing → Human computer interaction (HCI)**; **Accessibility**.

Keywords

Deaf and Hard of Hearing, Children, Social Play, School Ecosystem, Field Study, Peer Culture

ACM Reference Format:

Jing Zhao, Isabel Neto, Michaela Okosi, Paulo Vaz de Carvalho, and Hugo Nicolau. 2026. Social Play Between Deaf and Hard of Hearing Children and Hearing Peers: Learning from Children and School Ecosystems. In *Proceedings of the 2026 CHI Conference on Human Factors in Computing Systems (CHI '26), April 13–17, 2026, Barcelona, Spain.* ACM, New York, NY, USA, 16 pages. https://doi.org/10.1145/3772318.3791520

1 Introduction

All children have the fundamental right to participate equally in play and recreation [76, 77]. Social play is an intrinsically motivated activity that serves no purpose beyond play itself, yet it is essential for development by fostering critical social skills [52, 66]. Moreover, social play holds a pivotal role in children's emotional and cognitive development [66], equipping them with the fundamental life skills necessary for thriving in broader society [52]. For Deaf and Hard of Hearing (DHH) children raised in hearing families without robust access to language learning (~ 90% [51]), social play can serve as a critical pathway for incidental language acquisition and literacy development [55]. However, studies indicate that DHH children experience persistent challenges in social interactions and social play with hearing peers [8, 72].

Recently, a growing body of human-computer interaction (HCI) research has focused on facilitating social play and interactions among children with varying abilities, aiming to promote inclusion and enhance overall well-being [22, 38, 41, 53, 56, 57, 62, 85]. For instance, Neto et al. designed a multisensory tactile storytelling robot to support interactions among groups with mixed-visual abilities [57]. Jones and colleagues examined strategies for initiating and sustaining joint attention within mixed-visual ability groups in complex situations [38]. Furthermore, researchers have advocated for bidirectional social interaction and play among neurodiverse groups. They have employed interdependent [41] or double empathy [52] frameworks to foster engagement and reduce social exclusion. However, research addressing mixed-hearing ability settings remains limited [90]. DHH children, as linguistic and cultural minorities in hearing-dominant societies, exhibit distinct social behaviors, collective norms, educational practices, and other cultural forms that differ from mainstream hearing cultures [10]. Therefore, we argue that their interactions and play present unique and complex social and cultural challenges.

Children and their physical and social environments are mutually dependent, as illustrated by Bronfenbrenner's ecological model of child development [19]. Children's play occurs in a range of immediate settings, or microsystems, such as school, home, street, friends' houses, and natural environments. These microsystems play a crucial role in shaping children's play and development [70]. Research indicates that the school microsystem, as an ecosystem directly influencing children's daily play activities [84], is a critical context for social play and friendship building within mixed cultural groups[5]. Yet, how the school cultural microsystem affects the social play behavior of DHH children with their hearing peers on the playground, and what challenges and opportunities exist in social play for children growing up in hearing and deaf cultures, remain underexplored.

In this paper, we aim to investigate the potential of technological design to support DHH children in engaging in social play with hearing children on the playgrounds across different cultural ecosystems. Without a deep understanding of the social play dynamics between DHH and hearing children, there is a gap between existing social play interaction paradigms and the design for effective, inclusive solutions for them. We address two core research questions: *RQ1: What are the social play experiences between DHH children and hearing peers in varying school cultural ecosystems? RQ2: What technology design opportunities emerge to support inclusive social play for children in mixed-hearing school playgrounds?* To investigate these questions, we conducted three studies in two integrated schools, each embedded within a distinct cultural ecosystem by a child-centered and multi-perspective approach (see Figure 2). The first two studies were conducted at a partially bilingual school (referred to as Partially Bilingual School), which provides a bilingual environment exclusively for DHH children, with sign language classes offered mainly to DHH students. To further explore how mixed-hearing children engage in social interaction and play, the third study took place in a whole bilingual school (referred to as Full Bilingual School), where all students learn sign language and share a common communicative foundation.

(1) We adopted drawing and interview techniques [40] to understand how groups of children with mixed hearing abilities perceive and experience social play on playgrounds.
(2) We held semi-structured interviews with four teachers, a special education teacher, and a preschool educator to gain insight into the social play of children with mixed hearing abilities within the school ecosystem.
(3) We conducted a 7-week (26 days) observational study to explore the characteristics of social play among children with mixed hearing abilities.

Based on the analysis of the above research, we first discovered that at the Partially Bilingual School, hearing and DHH children rarely engage in social play on the school playground, as indicated

by interviews with mixed-hearing children and their educators. Distinct language use and a lack of bicultural awareness emerged as principal challenges to their social play. In addition, our long-term field observations at the Full Bilingual School revealed that the absence of peer culture and limited child agency were primary barriers to social play among mixed-hearing children, while the presence of trusted friends and collaborative play tools served as key facilitators. Reflecting on these findings, we propose a contextualized social play technology design space: technology should coordinate and facilitate the co-creation of peer culture and children's agency in the contextualized school culture ecosystem to support the social play among mixed-hearing children (see Figure 1).

2 Background & Related Work

In this section, we present an overview of previous research on technology for DHH children in HCI, highlighting the distinction between the predominant focus on academic participation and the broader context of everyday interaction and social inclusion. We then discuss related work in HCI on supporting the social interaction of mixed-ability children. Finally, we conclude with a review of research on social play and the influence of school ecosystems on children's play behaviors.

2.1 Technology for DHH Children in HCI

Developing digital technologies for DHH children has been extensively explored in HCI [90]. Existing research has primarily addressed sign language learning [4, 9, 17, 25, 34], literacy and mathematics education [1, 3, 21, 27, 28, 74], and assisted communication [2, 6, 12, 13] to promote the inclusion and well-being of DHH children. While these studies illustrate that current technological approaches frequently emphasize academic participation for DHH children [29], there remains a substantial gap in understanding how technology can facilitate informal social interactions and interpersonal relationships that foster inclusive education in everyday settings such as the playground [42].

According to Eriks-Brophy et al., there are three core benefits of inclusive education for DHH children: increased social interaction and contact with hearing peers, natural acquisition of language and behavioral patterns from hearing peers, and greater social acceptance by hearing peers [26]. As more children with hearing loss are integrated into mainstream schools, opportunities for socialization with hearing peers increase, which is essential for the development of social skills and social integration [59]. Play serves as an effective context for fostering appropriate interactions, such as sharing, turn-taking, initiating and responding to social communication [16], and promoting incidental learning [55]. However, recent research has found that DHH children are often overlooked or excluded from social play with hearing peers in school playgrounds [72]. This exclusion may stem from a lack of awareness regarding differences in communication and socialization between each other [24]. DHH children primarily rely on visual cues for communication during play, while hearing children predominantly use auditory communication [72]. In addition, DHH children are often perceived as "different" by hearing children and may be excluded or intentionally ignored [72]. Even those DHH children with advanced language and social skills may still experience exclusion from social play [88]. DHH children find it difficult to initiate play with hearing peers, and hearing peers rarely invite or allow DHH children to join in play [72]. Recent technology design has started to shift toward fostering inclusive social play and interaction in HCI and accessibility communities [14, 66]; yet, this is still rare for mixed-hearing ability groups [90]. To advance technology design toward supporting everyday social interaction for DHH and hearing children, we aim to explore the potential design directions by systematically understanding the social play experiences of mixed-hearing children in school playgrounds.

2.2 Technology Supporting Social Interaction of Mixed-ability Children in HCI

The use of technology to promote social interaction among heterogeneous groups of children and to foster social play and inclusion has become an increasingly prominent focus within HCI research [66]. A substantial body of work has targeted assisting mixed visual ability children in inclusive educational settings. These include the robots that mediate group conversations, facilitate social participation, and interactions [56–58], as well as the creation of collaborative coding environments for both remote and co-located contexts [63, 64], and the co-design of collaborative tools to support creativity and teamwork [23, 62]. Furthermore, emerging research aims to support free and self-motivated social play to enhance the sense of belonging and well-being of neurodiverse children [30]. For instance, Morris et al. co-designed and developed the "ChromaConnect" prototype with neurodiverse children, which allowed participants to establish a shared language of play, increase the visibility of diverse play patterns, and encourage explicit initiation of social play behaviors [53]. Similarly, Werner and colleagues worked with neurodiverse children to design and evaluate two social play technologies, MusicPads and LightSpaces, highlighting the important role that technology can play in children's collaborative play experiences and spatial exploration [85]. In addition, researchers have emphasized the bidirectional process of social interactions and play, suggesting that challenges are rooted in mutual interpersonal dynamics rather than being attributable to a single group [30, 41, 52, 66].

However, many existing technologies are not designed for DHH children who use sign languages in auditory-centric environments, which puts them at risk of social isolation. Differences in languages can lead to differences in social behaviors, norms, and other expressions of human knowledge [10]. For example, Deaf cultural norms center on visual, spatial, and embodied communication [44], while sound is the primary communication mode in hearing culture. Societal expectations from the hearing majority often create additional challenges for DHH children [37]. Previous intervention programs aimed at increasing peer interaction often involved teaching specific interaction skills to DHH and/or hearing children, instructing sign language and/or providing knowledge about deafness to hearing children, and designing educational environments that naturally promote interaction. Results show that these interventions can successfully increase interactions within DHH groups of children but have limited effects in mixed-hearing ability groups [8].

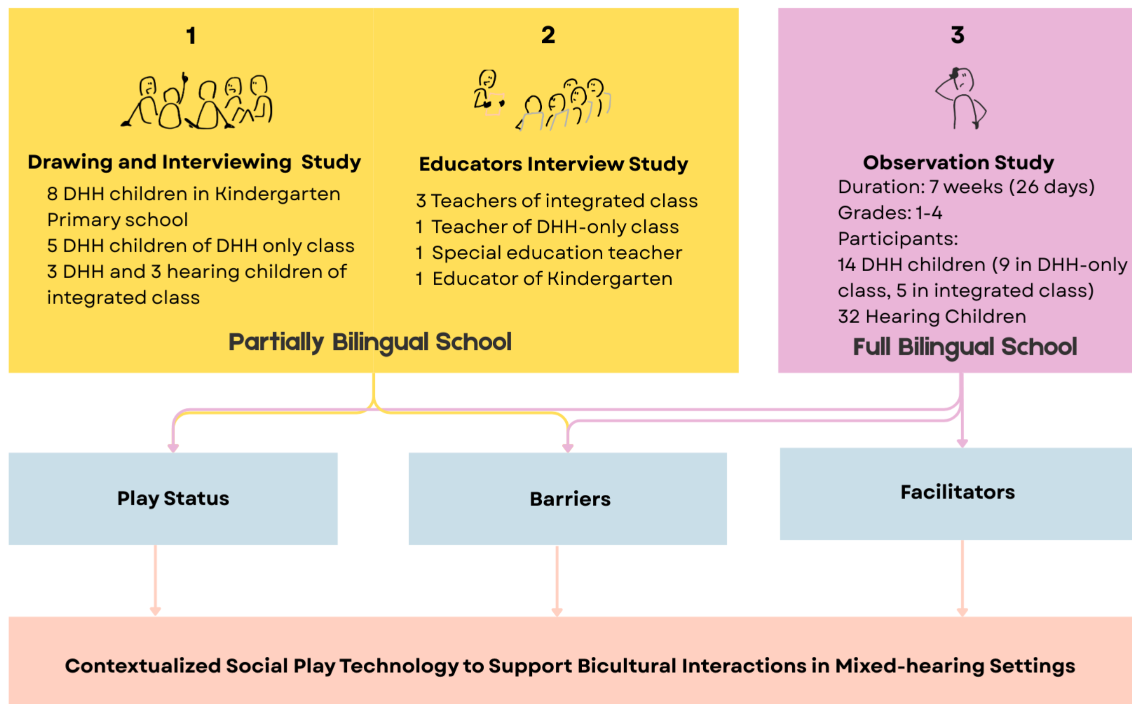

Figure 2: Overview of the research process we followed, including three studies across two schools and the resulting outcomes from each step.

There is increasing recognition that the children's involvement and understanding of their attitudes are essential for designing technology that effectively supports social interactions and play for them [30, 45, 52, 73]. Research in psychology and physical education indicates that participatory methods, such as story games, concept mapping, drawing, and writing, are developmentally appropriate for eliciting children's views on social play [40]. Building on this body of work, we present a need assessment study to inform the design of social play technologies, with particular attention to the perceptions and experiences of children with mixed-hearing abilities in various inclusive educational settings.

2.3 Social Play and School Ecosystems

Social play is a free, spontaneous, and voluntary activity that involves interaction with more than one person, with a broader and less formally defined scope than games [11, 87]. Researchers often categorize social play along two complementary dimensions: social level and play behavior. The social level captures the degree of interaction among participants and the context, first articulated by Parten [60], which comprises six levels: unoccupied behavior, onlooker behavior, solitary play, parallel play, associative play, and cooperative play, representing an ascending continuum of social engagement complexity [66]. The play behavior dimension, rooted in Piaget's theory and further elaborated by Smilansky, categorizes play according to its cognitive and functional characteristics from games with rules, functional play, constructive play, to fantasy play [61, 65, 71], emphasizing the different types of children's play activities [36].

There is no universally accepted definition of social play. We follow Scheepmaker et al.'s definition in their paper on technology's role in social play, drawing from Vygotsky, Piaget, and Sciart: social play is an intrinsically motivated activity with no purpose other than play itself [66]. As illustrated by Bronfenbrenner's ecological model of child development, children's growth depends on their physiological and social environments, which are arranged in a four-tiered nested structure: micro-, meso-, exo-, and macro-systems [19]. The microsystem comprises the everyday settings in which children play, such as school, peers, family, and community. The dynamics within these microsystems significantly influence children's play experiences [19, 70].

Although Bronfenbrenner initially placed culture at the macrosystem level, recent researchers have highlighted the influence of *cultural microsystems* on children's development. They argue that culture is not an independent system separate from the micro-level, but rather a linguistically mediated system of meaning construction that exists within everyday actions (activities, routines, practices) and as part of a community of practice [84]. The cultural microsystem framework is deeply influenced by Vygotsky's research, as he was the first researcher to consider culture as an instrumental factor in child development and play [5, 84]. In his sociocultural theory, the external use of culturally defined tools and signs is later internalized during child development. The process of cultural

development in children occurs first at the social level, between individuals, and later at the individual level, i.e., internal to the child, and this process arises during infancy [83, 84]. Concurrently, play is a social behavior that drives children's development, being shaped by social relationships and structures [66, 82]. Later, Hedegaard expanded Vygotsky's theory to include institutional practices and their activity environments that condition children's activities [31, 32]. Based on Hedegaard's model, children's motives and competences in social situations are influenced by formal sociocultural traditions, informal institutional practices such as schools, families, and daycare centers, and specific shared activity contexts [32]. As children adapt to new social contexts, their social practices also evolve, creating new social futures [78].

School playgrounds are intentionally designed spaces for children's social play [68], yet the role of the school cultural ecosystem in play has long been overlooked. Adams and Quinoes investigated how immigrant children enrolled in international schools establish friendships in a new country and school setting. They found that cultural differences significantly affect social play and friendship formation, and that adult-created conditions shape children's interactions across settings [5]. However, research on cultural microsystems regarding peer interaction patterns, social play preferences, and school cultural practices, and how these influence the social play behavior of children with DHH and hearing peers raised in different cultural contexts, remains limited. Thus, we aim to explore the impact of school cultural ecosystems on the social play behavior of children with mixed-hearing abilities, as well as to identify opportunities for designing technologies that promote social play and, in turn, influence the school's cultural ecosystem.

3 Methodologies

To answer our research questions, we adopted a multi-perspective qualitative research approach in two schools with different cultural ecosystems (Figure 2), combining child-centered drawing and interviews, adult stakeholder interviews, and long-term observation methods, with inductive and deductive thematic analysis.

3.1 Research Sites

3.1.1 Partially Bilingual School. In 2008, this school was designated by law as an inclusive school for bilingual education for DHH students, including preschool, primary, and secondary education. DHH students can be enrolled in DHH-only classes or integrated into mainstream classes. However, DHH students did not begin receiving secondary education until the 2015/2016 academic year. Currently, DHH children in DHH-only classes receive their education primarily in sign language, whereas those in integrated classes or classes with only hearing children do not receive sign language education. The decision to transition a DHH child into an integrated or a DHH-only classroom is made by the preschool educator based on a comprehensive assessment of the child's social skills, communication abilities, spoken language skills, and their ability to perceive speech from hearing individuals (e.g., through assistive devices).

3.1.2 Full Bilingual School. Since 1913, this school has offered teacher training courses specifically for DHH students. It includes preschool, primary, secondary, and vocational education. DHH students can form classes for the DHH or be integrated into mainstream classes. Although classes for DHH children are taught in sign language, all mainstream classes from preschool to primary school offer regular sign language courses. The Full Bilingual School play-

Figure 3: The playground at Full Bilingual School where we conducted observation.

grounds include tables and chairs for drawing and writing, as well as spacious physical activity areas (as shown in figure 3). Additional facilities include two toy rooms (with dolls, Lego, board games, etc.) and a television room. The school provides play equipment (such as footballs, rackets, jump ropes, roller skates, skateboards, scooters, paintbrushes, Lego, and dolls) for use. During the school day, playground assistants supervise recess during morning and afternoon breaks, as well as during lunch. During summer vacation, playground assistants supervise playtime for a month. This area is available for primary students in Grades 1 through 4.

3.2 Participants

3.2.1 Partially Bilingual School. A total of 19 children participated in the drawing and interview study (Table 1). They were from three classes: 8 from the DHH-only preschool class, 5 from the DHH-only class from primary school Grades 1 through 4 (ages from 7 to 11), and 6 from the integrated class in primary school Grade 2 (3 DHH children and 3 hearing children). All children's interviews were conducted with written informed consent from their caregivers, and only children who voluntarily agreed to participate were interviewed. Additionally, teachers were present throughout the interviews to ensure a safe and supportive environment. The study was reviewed and approved by the authors' institutional ethics board.

Six adult stakeholders participated in the interview study (Table 2). Three primary school teachers of integrated classes (Grades 1-4)

Table 1: Background information of DHH and hearing children from the Partially Bilingual School who participated in the interview session

Grade Level	Class Type	ID	Hearing Status	Age	Gender	Language Mode	Parents Hearing Status
Kindergarten	DHH only class	DK1	Profound deafness	5	M	Sign language	DHH
		DK2	Profound deafness	5	F	Sign language	DHH
		DK3	Profound deafness	7	M	Sign language	Mother: Hearing; Father: DHH
		DK4	Profound deafness	7	M	Sign language	DHH
		DK5	Profound deafness	5	F	Novice sign language	Mother: Hearing;
		DK6	Profound deafness	6	M	Bilingual	Mother: Hearing;
		DK7	Profound deafness	5	F	Bilingual	DHH
		DK8	Profound deafness	5	F	Novice sign language	Mother: Hearing;
Primary School	DHH only class	DP1	Profound deafness	8	M	Sign language	Hearing
		DP2	Profound deafness	11	F	Bilingual	Hearing
		DP3	Profound deafness	9	F	Sign language	Hearing
		DP4	Profound deafness	14	M	Sign language	Hearing
		DP5	Profound deafness	13	M	Sign language	Hearing
	Integrated class	HOH1	Profound deafness	9	M	Bilingual	DHH
		HOH2	Profound deafness	8	M	Bilingual	Hearing
		HOH3	Profound deafness	8	F	Bilingual	Hearing
		H1	Hearing	8	M	Oral	Hearing
		H2	Hearing	9	M	Oral	Hearing
		H3	Hearing	8	F	Oral	Hearing

Table 2: Background information of educators from the Partially Bilingual School who participated in the interview session

ID	Hearing Status	Profession	Gender	Years of Experiences with DHH childern
T1	Hearing	Teacher	F	15 Years
T2	Hearing	Teacher	F	4 Years
T3	Hearing	Teacher	F	1 Year
T4	DHH	Sign language Teacher	F	11 years
ST1	Hearing	Special Education Teacher	F	19 years
PE1	DHH	Preschool Educator	F	More than 5 years

and 1 special educator participated in a semi-structured group interview; a DHH teacher of the DHH-only class and a DHH preschool educator participated in a semi-structured interview. These professionals had extensive experience in educating DHH children. The interview study was reviewed and approved by the authors' institutional ethics board.

3.2.2 Full Bilingual School. A total of 46 children (aged from 7 to 10 years) participated in a 7-week (26-day) observational study. They were from Grades 1 to 4, across five classes (four integrated classes and one class for only DHH children). Among them, nine were from the class for only DHH children, and five DHH children were from integrated classes in Grades 1 to 4 (Table 3). Thirty-two hearing children were from Grades 1 to 4. During our seven-week observation period, the number of children under observation fluctuated, with a minimum of 18 children present during the study. Additionally, according to observation notes, 16 hearing children regularly appeared on the playground for social play. They played on the same playground during recess and summer vacation. The observation study was reviewed and approved by the authors' institutional ethics board.

3.3 Methods

3.3.1 Study 1: Drawing and Interviewing Study. The drawing and writing method has been widely used to study children's cognition of physical activity and sports, physical education, and the learning of sports skills. It has been proven to be an effective technique for children, allowing them to express their feelings about playtime through drawing and writing, thereby enabling them to articulate their opinions and perspectives on social play experiences. Specifically, this can be achieved by listening to children's narratives while they draw [20, 35, 40]. The drawing and interviews were conducted in person. Each session lasted approximately 20-30 minutes. All students in the three classes participated in the drawing activity. The researcher introduced the drawing activity in the classroom, distributed drawing sheets, and asked the children to draw their happy and sad moments on the playground, following the prompts on the

Table 3: Background information of DHH children from the Full Bilingual School who participated in the observation session

Class Type	ID	Hearing Status	Language Mode	Age	Gender
DHH only class	DP6	Profound deafness	Sign language	8	F
	DP7	Profound deafness	Sign language	8	F
	DP8	Profound deafness	Sign language	9	F
	DP9	Profound deafness	Sign language	11	F
	DP10	Profound deafness	Sign language	9	M
	DP11	Profound deafness	Sign language	6	M
	DP12	Profound deafness	Sign language	approx. 8–9	M
	DP13	Profound deafness	Sign language	10	M
	DP14	Profound deafness	Sign language	approx. 9–10	M
Integrated class	HOH4	Hard of Hearing	Bilingual	7	F
	HOH5	Hard of Hearing	Bilingual	approx. 7–8	F
	HOH6	Hard of Hearing	Bilingual	approx. 7–8	F
	HOH7	Hard of Hearing	Bilingual	10	M
	HOH8	Hard of Hearing	Bilingual	approx. 7–8	M

sheets. Following the drawing activity, the children in the DHH-only classes who had completed their drawings were interviewed. Given the children's varying levels of sign language proficiency, educators and sign language interpreters assisted the researchers in communicating with the children. For the integrated class, three DHH children and three hearing children volunteered to participate in the interviews. All interviews were audio-recorded, transcribed using the OpenAI Whisper tool [1], and reviewed. The interview questions began with participants describing their drawings (usually including the type of play, friends, and difficulties encountered), their status in social play with peers with different hearing abilities, and the barriers and opportunities they encountered.

3.3.2 Study 2: Interviewing School Care Ecosystem. We conducted our semi-structured interviews face-to-face, each lasting 30-60 minutes. Sign language interpreters were present to assist with translation during interviews with the DHH preschool educator and the DHH teacher of the DHH-only class. All interviews were recorded and subsequently transcribed using the OpenAI Whisper tool [1]. The interview questions covered participants' perspectives on the patterns of social play among mixed-hearing children, the challenges and barriers they encountered during social play, and the strategies they used to address these challenges.

3.3.3 Study 3: Observations on the Playground. The observation period lasted seven weeks (26 working days), including two sections: first, a two-week (6 working days) class break (30 minutes) and lunchtime recess observation (30-45 minutes); second, a five-week (20 working days) daily summer observation for approximately 5 hours. During the observation period, the first author observed social play behaviors, initially referencing the modified SOPARC Tool [36], which includes assistive device status, activity level, play behavior, and social level. Meanwhile, barriers and facilitators were noted. From the second week, researchers made adjustments based on practical circumstances: participants were labeled, hearing levels within play groups were recorded, and activity level was redefined to include activities beyond play behavior, such as talking.

3.4 Analysis

We conducted thematic analysis (TA) of interview transcripts and observation notes using the methodological frameworks outlined by Clarke and Braun [18], and McDonald et al [48]. For the interview transcripts, the first and third authors initially performed inductive coding on all data separately. Second, the first and third authors discussed the initial codes iteratively to reach consensus on interpretations and themes, thereby establishing the thematic structure. This theme structure was further refined through discussion and revision by all authors.

For observation notes, the first author anonymized the data, assigned participant codes, and sorted the material. Secondly, based on data interpretation and a modified Social Play Observation Tool (SOPARC) from literature [36], challenges and facilitators related to the research questions were developed into an initial coding book. Thirdly, the first and third authors independently performed deductive coding on all observation notes using the initial coding book. During coding, both authors collectively negotiated consensus on each observation note, and the final coding book was formed through iterative discussion (see Table 4). In addition, initial themes were jointly established and continuously discussed until final themes emerged.

4 Findings

The data indicate that the distinct cultural ecosystems of the two schools influenced the social play of mixed hearing children, along with the multiple perspectives and positions of child and adult stakeholders. This section presents an overview of social play among children with and without hearing loss in both schools, then examines factors that either facilitate or hinder play for children with mixed-hearing abilities.

[1]https://github.com/openai/whisper

Table 4: Definitions of codes in the observations

Code	Definitions
Mixed Ability (Y/N)	The hearing status of children participating together was categorized into mixed groups: (1) Deaf, Hard of Hearing children; (2) Deaf and hearing children; (3) Hard of Hearing and hearing children; (4) Deaf, Hard of Hearing, and hearing children; and non-mixed groups, namely Deaf children and hearing children.
Social Level [47]	
Peer play	Instances when two or more children play in an activity-oriented way and mutually acknowledge each other. The children's actions are complementary with those of another/others, and/or the children are engaged in conversation about a common activity.
Play with an adult	Instances where a child is engaging in play with an adult (e.g., parent, caretaker).
Solitary	Instances where a child plays alone or independently, makes no reference to others and makes no effort to include other children in his or her play.
Parallel	Instances where a child plays independently beside, but not with, another child. The child does not try to influence others in play.
Play behavior [47]	
Constructive	The child's activity is goal-oriented and thoughtful. They are using materials to create something (e.g., using rocks to make a structure.
Dramatic/Fantasy	Child takes on imaginary roles or use objects to represent something imaginary (e.g., children playing "house" or pretending to be animals).
Functional	Play activities involving repetitive muscle movements (e.g., running, walking), vestibular stimulation (e.g., rocking back-and-forth, swinging, jumping, spinning, rolling on the ground), or proprioceptive stimulation (e.g., climbing, pushing, pulling, carrying heavy objects).
Games with Rules	Games with universal rules, such as tag, dodgeball, and hide-and-seek.
Non-play	The child is not involved in any of the above play behaviors. Examples of non-play behaviors include unoccupied/onlooker play (i.e., watching others), being between activities, and sitting.
Waiting	Children are not engaged in play because they are waiting to use equipment (e.g., waiting to use the swing).
Activity	Activities where children engage in social interactions on the playground but are not playing (e.g., talking, lying down together, and conflicts).
Challenges Observed	Challenges encountered by children in mixed groups during social play included difficulties in initiating, joining, and sustaining play.
Facilitators Present	Facilitators for children in mixed groups during social play, specifically under which conditions children in mixed groups can engage in social play.

In the **Partially Bilingual School**, Deaf children in DHH-only classrooms, as well as HOH children and hearing children in mainstream classes, rarely engage in social interactions at school, playing in separate spaces and groups. The majority (n=9) of Deaf children at the primary and kindergarten levels reported playing exclusively with other Deaf students at school, although some Deaf children played with hearing peers outside of school. Hearing and HOH children in mainstream classes both reported playing together. However, interviews with teachers indicated that HOH children (n=3) transitioning from DHH-only to mainstream classes can experience a dilemma of being rejected by both groups, triggering crises in language and identity development (T2).

At the **Full Bilingual School**, children are integrated into mixed-hearing play groups, regardless of hearing ability. Although primary play groups are class-based, children also participate in social play, such as jump rope and ball games, together. It is important to note that HOH children in mainstream classes are welcomed by both Deaf and hearing children in their respective classrooms and often serve as bridges for building friendships and resolving conflicts.

4.1 Barriers to Social Play among Mixed-Hearing Children

During our analysis, we identified three dimensions of barriers to social play experienced by children with mixed hearing abilities: school culture in the Partially Bilingual School, peer culture, and personal agency in the Full Bilingual School. We will discuss each dimension in the following sections.

4.1.1 Dilemmas in Bilingual and Bicultural Development at the Partially Bilingual School . **The primary obstacles to integrated play among children with mixed-hearing abilities at the Partially Bilingual School arise from two key deficiencies in campus culture: the absence of bilingual education and limited bicultural awareness.** The lack of bilingual education diminishes the motivation for children with varying hearing abilities to

interact. Most children (n=9) from DHH-only classes reported that their hearing peers' lack of sign language proficiency prevented them from engaging in play together at school. For example, DP2, who possesses oral language skills, played exclusively with DHH peers at school and only socialized with hearing children outside of school. As DP2 explained: *"I don't want to play with hearing kids (at school) because they don't know sign language."* Similarly, for hearing children, the absence of bilingual education restricts their exposure to and interest in the minority Deaf culture present on campus. According to PE1, two years ago, when all students learned sign language, children with mixed hearing abilities could interact with each other during breaks. Moreover, T4 and T1 emphasized that sign language fluency was a barrier: *"(Currently), hearing children don't play with Deaf children. Deaf children communicate quickly in sign language. And few hearing children are interested in sign language."*

In addition, delayed literacy development among Deaf children, resulting from insufficient accessible learning materials, further restricts their social interactions with hearing peers. As ST1 highlighted: *"Learning to read and write is crucial for Deaf children to keep pace with their hearing peers, but schools must adapt teaching materials and methods."*

Furthermore, insufficient bicultural awareness within school education significantly impairs the social interactions of children with mixed hearing abilities. This challenge is evident in the sense of belonging and identity crisis experienced by HOH children when transitioning from DHH-only classes to mainstream classes (HOH1-3). T2 explained, *"In DHH-only classes, HOH children formed close bonds with peers of similar hearing status. Those peers were their closest relationships."* Although HOH children are bilingual, *"they often prefer to use sign language for communication. This leads to the HOH child feeling frustrated during play."* ST1 also noted that, *"after leaving the DHH class, the HOH child faces rejection. His former DHH classmates don't like him (because of leaving), and his new, hearing classmates also cannot accept him,"* which traps him in a state of social marginalization. Furthermore, the school's inability to foster an inclusive campus culture has hindered the realization of individual potential and impeded social inclusion. As T1 and ST1 pointed out, the absence of a supportive campus culture and the lack of appropriate standards for assessing individual potential and providing tailored developmental support have limited students' comprehensive development.

The following section presents findings from a long-term study of playground observations at the Full Bilingual School, which offers bilingual education to children with and without hearing loss. This study identifies the practical challenges that children with mixed hearing abilities encounter during social play.

4.1.2 Disparities in Peer Culture during Mixed-Hearing Social Play in the Full Bilingual School. Peer culture refers to activity and relationship patterns constructed by children through daily interactions, representing shared understandings, values, and beliefs, establishing standards and norms for peer inclusion, and defining acceptable behavior in social play [87]. **At the Full Bilingual School, observations indicated that DHH and hearing children often played socially under different peer cultural assumptions, including approaches to joining play, interpretations of norms, communication, and modifications of rules, and perceptions of assistive devices. These differences unintentionally limited opportunities for sustained mixed-hearing play.**

A significant difference appeared in *play initiation.* DHH children commonly used helping behaviors, such as picking up toys, to signal their interest. For example, DP6 attempted to join a ring-toss game of hearing groups by retrieving rings, a gesture intended as cooperative. The hearing children accepted the assistance but did not interpret it as a request to join. Shortly after, a hearing child verbally requested a ring and was immediately included (Day 25). This mismatch between implicit, help-based bids and explicit verbal requests often meant that DHH children's attempts went unnoticed.

Interpretive norms also differed between groups. For example, DP6's attempt to repair a broken doll was misinterpreted by hearing peers as an attempt to take it (Day 15). During a mat activity, a hearing girl verbally and physically demanded more space. DP6, unable to obtain a further explanation, appeared confused and hurt (Day 16). Physical play also led to similar misunderstandings: hearing children's playful *"attacks"* were perceived as unfriendly by DHH peers, while DP14's imaginative *"kidnapping game"* was judged *"too violent"* by hearing children (Day 3).

Communication preferences during playground play directly influenced participation and duration of mixed-hearing interactions. Hearing children typically relied on rapid verbal coordination, such as calling out rules, slogans, or instructions during games like chase or football, whereas many DHH children communicated through sign language, gestures, or visual cues. These communication modes rarely aligned naturally, and the responsibility for adaptation often fell on DHH children. For example, during a racing game, *"DP9 helped time the race and discussed with HOH7 using sign language,"* but after HOH7 left, the remaining hearing children coordinated entirely through speech. *"DP9 could not follow and left,"* despite the activity requiring minimal spoken language (Day 11). This mismatch also hindered DHH children's ability to adapt to rule changes during gameplay. In another case, hearing children *"shouted slogans to decide who to catch,"* while DP9 followed only the movement, not the rules, causing the game to dissolve quickly (Day 11). These moments demonstrate that mismatched communication preferences, rather than motivation or interest, often disrupt children to sustain shared play. However, when children actively adapted their communication, mixed-hearing play was successful. During football, *"the hearing boys responded in sign language when the DHH boy spoke,"* which allowed the game to continue smoothly (Day 6).

Communication preferences also shaped the participation of hearing children when DHH groups used sign language. For example, a hearing girl who sat with several Deaf children *"could not follow their signed conversation and eventually went to talk with hearing peers instead"* (Day 15), indicating that both groups experienced challenges when their preferred communication modalities were not mutually accessible. Hearing friends of HOH5 *"learned sign language from HOH5 and HOH7 to communicate with Deaf children,"* which expanded participation beyond their immediate peer group (Day 14). Throughout the observations, HOH children frequently acted as informal mediators, *"translating between Deaf and hearing peers"* and facilitating conflict resolution and turn-taking (Days 3, 7, 9, 15). These cases demonstrate that communication mismatches are not insurmountable barriers; rather, shared effort and mutual

accommodation can transform brief interactions into sustained, inclusive social experiences.

The use of *assistive devices* introduced another cultural divide. DHH children were aware of the fragility of Cochlear Implants (CIs) and Hearing Aids (HAs), which influenced their choices during play. For instance, *"DP7 avoided jump roping due to concern about losing her CI"* (Day 5). In contrast, hearing children, who were unfamiliar with these considerations, sometimes responded dismissively. In another instance, when *"HOH4's device fell during play, her hearing peers did not notice; only a passing hearing child alerted her"* (Day 19).

4.1.3 Agency Shifts with Context and Group Dynamics in the Full Bilingual School. Children who possess agency in social play demonstrate ownership and control, actively shaping their social environment and establishing new peer cultures through interactions with others [89]. **At the Full Bilingual School, the agency shifted fluidly between DHH and hearing children depending on group composition, communication patterns, familiarity, and prevailing norms.** By the middle stage of the observation period, DHH children were frequently positioned in passive roles during mixed-hearing play, often observing or imitating rather than leading. For instance, during clapping games, *"HOH4 watched nearby but did not join because she did not know the rules"* (Day 18). In another session, *"DP9 watched a body movement game, tried to understand, and then left,"* unable to gather enough cues to participate (Day 12). Even when in close proximity and interest, *"DP9 watched and tried to understand what they were playing,"* yet did not interrupt or assert a turn (Day 15). These examples indicate that rule ambiguity, rapid interaction, and unfamiliar play structures can inhibit DHH children's ability to act with confidence and agency.

Shifts in group power and dynamics could immediately alter which children held control within the group. For example, a HOH child who initially played football with two hearing peers *"became an onlooker when a new hearing child joined,"* thereby losing access to the shared rhythm of the game (Day 4). In contrast, during a bubble activity, the dynamic reversed: a hearing boy withdrew when communication shifted into signing, allowing the DHH children to continue the game without him (Day 7). These instances demonstrate that agency was not determined solely by hearing status, but by the interplay of communication mode, familiarity, and the unwritten norms shaping each activity. In this context, agency was relational and emerged from the group interactions rather than from the individual child alone.

Over time, sustained contact and increased familiarity appeared to reshape group dynamics. As children spent more days together on the playground, DHH children increasingly initiated interactions and participated actively in play. By the mid-to-late observation period, they frequently initiated play with hearing children, approached peers independently, and began resolving conflicts without relying on HOH children or adults to mediate (Days 15, 19, 22, 25). In several sessions, the pattern reversed: DHH children led games such as chase, pretend performances, or coordinated group running, with hearing peers joining seamlessly (Days 21, 22, 26). These developments indicate that agency became more evenly distributed as children gained shared experiences, established routines, and built confidence through repeated interactions.

Taken together, these patterns suggest that agency is not fixed or inherently linked to hearing status. Instead, agency evolves over time as familiarity and opportunities for meaningful contact increase. Early in the observation period, communication mismatches or peer cultural differences often limited DHH children's influence in social play. As children developed shared repertoires of play, including common rhythms, shared rules, and basic communicative strategies, the agency of DHH children increased, resulting in more coordinated, reciprocal, and collaborative mixed-hearing play.

4.2 Facilitators Support Social Play for Mixed-Hearing Children in the Full Bilingual School

During our playground observation at the Full Bilingual School, we identified key factors that promote social play among children who are DHH and their hearing peers.

4.2.1 Indirect Friendships as a Bridge for Social Network Development. We have often observed that interactions among children with mixed-hearing abilities increase as they spend more time and have more opportunities to interact on the playground during the summer holidays. A significant facilitating factor is the *"friend of a friend"* effect, in which a friend's friend becomes a trusted play partner and helps expand social networks. Both DHH and hearing children exhibit lower acceptance thresholds and higher trust toward peers with whom they share existing friendships. Indirect social ties reduce barriers during initial interactions. For example, as interactions increased between DHH children in the integrated class (HOH5 and HOH7) and the Deaf child (DP9), they engaged in casual conversation (Days 3 and 7) and played games together (Days 5, 7, 8, and 11). Subsequently, *"two close friends of HOH5 began playing with DP6-DP9, DP11, and DP13."* This process led to the formation of stable play relationships between mixed-ability peer groups, deepening mutual understanding and fostering a new peer culture. For instance, hearing peers began learning sign language (Days 11, 13, and 14) to participate in the social play of DHH children, adapting their communication patterns and social norms (Days 21, 22, and 25).

4.2.2 The Importance of Collaborative Play Tools. In our observations, cooperative play tools (96 out of 382), such as playing football or jumping rope, were the most frequent type of social play among mixed-hearing children. These collaborative play tools are appealing to children, as illustrated by the observation: *"When they play ball, DP11 cannot fully follow their discussion of rules but still joins based on his observation of behaviors (Day 7)."* Such activities foster agency and feature clear, simple rules and low barriers to entry, enabling active participation from all children. For example,*"From 4 children, eventually 16 children (including three DHH children) played jump rope together (Day 3)."* This process increases interaction opportunities for children with mixed-hearing abilities. Furthermore, play tools provided children with crucial opportunities to establish new interactions. Children were allowed to bring their own toys to share on the playground. Whenever new shared toys, such as skateboards, coloring books, cat-clawing sticky toys, or beauty tools, were introduced, they sparked the children's interest in exploration and increased their opportunities to interact.

Negotiating turn-taking or discussing rules during these activities offers opportunities for children to gradually understand, learn, and build peer culture, shaping their social future.

5 Discussion

Prior research has consistently documented disparities in playground engagement, with DHH children participating in solitary play more frequently than their hearing peers [72]. At the same time, efforts to support social play of DHH children in school settings have largely emphasized the development of individual communication and social-emotional skills [7, 43]. However, intervention programs targeting these areas have not increased social play behaviors between DHH children and hearing peers [8]; in some cases, interactions have even decreased [79]. Although HCI research on DHH children is growing, it has primarily focused on language learning and academic engagement [90]. Given the essential role of social play in children's cognitive, emotional, and holistic development, we investigated the challenges and facilitators of social play among mixed-hearing children across two schools with distinct cultural ecosystems.

In the following sections, we address our research questions. First, we summarize major findings and critically analyze how they align with or challenge existing accessibility models (RQ1). We then synthesize these insights into a novel design space and build on it to provide research opportunities on social play technologies for mixed-hearing groups (RQ2).

5.1 Beyond the Individuals: Culture Influences Social Play Experiences between DHH and Hearing Children (RQ1)

Our findings suggest that accessibility in play scenarios involving DHH and hearing children does not stem solely from mismatches in interpersonal communication or social skills. Rather, it is profoundly influenced by the cultural contexts — the hearing and Deaf cultures — in which these children are raised and educated. Our study of the Partially Bilingual School reveals how the absence of bilingual and bicultural support creates segregated play patterns between DHH and hearing children (Section 4.1.1). While language barriers prevented DHH children from playing with hearing peers, DHH children with spoken language skills still faced identity dilemmas, struggling to reconcile their Deaf identity with their ability to communicate with hearing children. This tension left them caught between two worlds, often feeling neither fully part of the DHH community nor fully integrated with hearing peers. This was reported when HOH transitioned from a DHH-only to a new mainstream classroom. They sometimes lost acceptance from former DHH peers and struggled to integrate with hearing classmates, which limited their participation in play.

In contrast, the Full Bilingual School demonstrated how a supportive cultural ecosystem—one that embraces both sign language and spoken language alongside awareness of Deaf and hearing cultures—facilitates inclusive social play. In this environment, DHH children with spoken language skills frequently served as cultural and linguistic bridges, resolving conflicts and fostering friendships across hearing differences (Section 4.2.1). These bridge-builders enabled collaborative play and conflict resolution that would otherwise be difficult to achieve. These findings align with recent research emphasizing that accessibility barriers are best understood and addressed through attention to contextual factors, where the broader cultural environment critically shapes how individuals navigate social interactions and overcome everyday challenges [14, 46].

Beyond institutional cultural ecosystems, our findings reveal the critical role of peer culture — the communication practices, play patterns, and informal norms that children co-create among themselves. In the Full Bilingual School, despite supportive bilingual infrastructure, the absence of a shared peer culture between DHH and hearing children remained a primary barrier to sustained social play (Section 4.1.2). Drawing on the "double empathy problem" [49, 50, 52], we understand these interaction challenges not as deficits within either group, but as mutual misalignments between different cultural practices. DHH and hearing children's interaction patterns naturally diverge due to their distinct linguistic and cultural backgrounds, creating opportunities for misunderstanding even in well-supported environments. This observation points toward a crucial design imperative: technological interventions for mixed-hearing play must actively mediate these peer cultural differences by scaffolding shared meaning-making and mutual understanding. Collaborative play technologies can play an important role (Section 4.2.2), but rather than simply accommodating existing communication modes, such technologies should facilitate the emergence of new, hybrid peer cultures co-constructed through the children's ongoing interactions [5].

Equally important is how children's agency in social play—their capacity to initiate, shape, and sustain play activities—emerges through dynamic interdependencies rather than individual abilities. Our observations (Section 4.1.3) demonstrate that DHH and hearing children's agency fluctuates based on group composition, communication modes, familiarity among participants, and informal norms. A child who confidently leads play in one context may struggle to participate meaningfully in another, not because of changing abilities but because of shifting contextual supports. This perspective aligns with Bennett et al.'s collaborative accessibility framework [15], which reframes accessibility as emerging from interdependent relationships among people, tools, and environments rather than residing solely in individuals or assistive technologies. For designers, this means creating systems that strengthen these interdependencies — tools that not only bridge communication gaps but also redistribute agency, enabling all children to contribute meaningfully to shared play regardless of hearing status.

5.2 Contextualized Social Play Technology to Support Bicultural Interactions in Mixed-hearing Settings (RQ2)

Building on our findings, we propose **"Contextualized Social Play Technology"** as a framework for designing inclusive play experiences that acknowledge and work with the cultural complexities of mixed-hearing environments (Figure 1). Unlike approaches that focus solely on individual skill development or assistive accommodations, this framework recognizes that social play emerges from three interdependent layers: the school's institutional culture,

the co-created peer culture among children, and each child's individual agency. These layers exist in a dynamic relationship: school culture shapes the conditions under which peer cultures form and children's agency is enabled or constrained; meanwhile, peer culture and agency mutually reinforce one another through social play, radiating outward to reshape the broader school culture. Our framework aligns with accessibility scholarship's evolution from medical models focused on individual deficits toward political/relational perspectives that understand disability as continuously negotiated through socio-material contexts [39]. From this view, accessibility in mixed-hearing play is not a fixed state to be achieved but an ongoing accomplishment produced through the interactions among institutional structures, peer dynamics, and individual actions.

This framework provides a structured design space that translates our empirical insights into actionable directions for future technology development. The design space we present is intentionally broad, offering multiple entry points for designers based on specific contexts and constraints rather than prescribing one-size-fits-all solutions.

The school ecosystem as design foundation. We argue that social play technologies need to be rooted in the cultural context of the school environment, reflecting the micro-environments children live in every day. Each school's cultural ecosystem—the educational programs, available resources, and strategies supporting children with hearing loss—determines which design interventions are feasible and effective [69]. Technology design must begin by understanding and working within the school's cultural ecosystem, particularly the three dimensions that emerged in our study: the linguistic environment (availability and status of sign language education), support for Deaf culture and minority cultural identities, and the physical/social structures that enable mixed-hearing interaction. Contextualized social play technology can strengthen each of these dimensions. For example, in partially bilingual settings where sign language may have a lower status, social play with bilingual interfaces and sign-language-based mechanics can elevate sign language's visibility and value, potentially shifting the linguistic ecology over time. Such schools may require play technologies that integrate bilingual learning and bicultural cultivation support, aligning with established play-based learning theories [75, 80, 86]. In full bilingual schools, technology can provide shared linguistic scaffolding, e.g., visual representations of concepts, multimodal feedback systems, and gesture-based controls, reducing communication bottlenecks during fast-paced play. These schools could implement tools that embed shared social norms within unstructured play to shape peer culture. Similarly, schools with limited teaching resources may need tools that facilitate peer interactions with minimal adult guidance. Critically, by embedding multimodal "interaction rhythms" (predictable patterns of visual, haptic, and auditory cues that structure turn-taking and role transitions), technology can create accessible participation structures that do not privilege auditory attention, thereby reducing the communication load that DHH children experience when relying solely on lipreading or interpreters in dynamic play contexts. Designing for specific contexts ensures social play technologies are relevant, practical, and aligned with children's lived experiences within particular school settings.

Co-creation of shared peer culture. Our findings revealed that even in supportive school environments, DHH and hearing children develop distinct peer cultures with different social norms, communication preferences, and play conventions, which hinder social play (Section 4.1.2). Moreover, previous research indicates that although some DHH children develop strong oral language and social skills, they are frequently excluded from social play [88]. Therefore, if researchers and designers focus solely on the communicative attributes of social play, they may inadvertently exacerbate structural inequalities. We emphasize that unstructured, spontaneous interactions depend heavily on peer acceptance and culturally supported relationship-building, which are the cornerstones of play and friendship development [5]. Distinct peer cultures manifest in everyday moments: hearing children often initiate play through verbal calls that DHH children do not perceive; DHH children employ behavioral engagement strategies that hearing children misinterpret or miss; assistive devices like cochlear implants become objects of confusion rather than normalized tools. We understand these misalignments not as deficits but as mutual gaps in cultural knowledge and communicative repertoires. Technology can mediate these gaps by making cultural practices visible and learnable during play itself. Rather than forcing assimilation to one group's norms, contextualized social play technology should scaffold bidirectional cultural exchange and co-creation. For instance, games might provide in-the-moment guidance about attention-getting norms in Deaf and hearing culture or be embedded in game mechanics. Technologies can also function as social infrastructure that expands peer networks—for example, collaborative challenges that require diverse communicative strengths create situations where bilingual children naturally serve as bridges. Through repeated interactions mediated by thoughtfully designed systems, children can co-construct hybrid peer cultures with shared norms and expanded communicative repertoires, similar to how visually impaired and sighted navigation partners develop shared spatial practices through coordinated interaction [81].

Building Children's Agency in Social Play. To facilitate social play among mixed-hearing children, social play technologies should support both peer bonding and individual agency within interactions. While social play is a social experience involving more than one person, it also depends on individual needs and agency. This insight centers on the task domain where technology facilitates dynamics between individuals and groups. Children's agency, i.e., their capacity to initiate play, maintain control over play direction, and assert their preferences, is fundamental to meaningful participation. Yet our observations showed how agency among mixed-hearing children remains fragile and context-dependent (Section 4.1.3). DHH children adopted onlooker positions when game rules were unclear, withdrew when group dynamics shifted toward auditory communication, and struggled to assert themselves when they perceived power imbalances. Social play technologies should balance group power dynamics during interactions and establish play frames that enable safe participation in several ways. First, it can reduce the knowledge barriers that undermine entry into play by providing accessible rule explanations, worked examples, or scaffold joining behaviors (e.g., detecting when a child is observing and offering prompts to join). Second, it can detect and respond to shifts in group dynamics—such as sudden increases in verbal

communication or changes in physical positioning—by introducing multimodal elements that redistribute communicative power. Third, it can provide DHH children with tools to assert their preferences or suggest play modifications without requiring verbal negotiation, while also allowing those who hesitate to safely withdraw from play. By actively scaffolding interactions, technologies can enable children to exercise agency while fostering meaningful social connections. This focus on agency responds to longstanding calls in Deaf education to strengthen children's self-advocacy and challenge ableist assumptions that position DHH children as passive recipients of accommodation [33, 54, 67]. By supporting children's ability to shape their play experiences, technology can foster their development as empowered social agents.

Overall, while this section focuses on technological possibilities, we highlight that addressing social play challenges requires coordinated efforts across multiple domains—pedagogy, policy, physical space design, and technology. Our emphasis on technology stems from its unique affordances: scalability across contexts, adaptability to diverse needs, and potential to introduce novel interaction possibilities that complement human efforts.

5.3 Limitations

While our study employed different methodological approaches at each school due to institutional contexts, future research could build on these findings by integrating drawing activities, interviews, and naturalistic observations across multiple school settings. This would provide a more comprehensive understanding of social play dynamics across varied educational ecosystems and cultural contexts. Additionally, expanding this research to include caregivers' perspectives presents a valuable opportunity to examine how family cultural environments influence and moderate children's social play experiences in both in-school and out-of-school settings, illuminating the interplay between home and school cultures in shaping inclusive social play. Finally, our study is limited by the number of DHH and hearing children at the Partially Bilingual School, where only three hearing children from mainstream classes participated alongside DHH students, which reflects the school's routine practices but may not fully represent the dynamics of more integrated mixed-hearing environments.

6 Conclusion

This study explored social play experiences of mixed-hearing children across two schools with distinct cultural ecosystems, involving 19 children and 6 educators at a Partially Bilingual School, and 7 weeks of field observations at a Full Bilingual School. We found that language barriers and struggles with belonging and identity constituted the primary obstacles to social play for mixed-hearing children at the Partially Bilingual School. Meanwhile, at the Full Bilingual School, where sign language education was provided to both DHH and hearing children, the absence of a shared peer culture and personal agency was the main challenge. Moreover, trusted peers and collaborative social play tools were identified as crucial facilitators of social play for mixed-hearing children. Reflecting on these findings, we proposed the concept of "contextualized social play technology", suggesting that technologies can foster children's personal agency and co-creation of a shared peer culture by promoting their social play and interactions, which must build upon contextualized school culture. We can envision multiple applications of contextualized social play technology to promote inclusive play experiences. For instance, tools could provide contextualized support for different play scenarios based on the situation, peer group composition, or children's preferred communication methods. Moreover, this concept can inform future evaluations of whether inclusive social play prototypes foster meaningful interactions among children from diverse backgrounds, especially those with different hearing abilities. Furthermore, this concept illuminates overlooked factors that influence daily interactions in inclusive education and can support educators and policymakers as a reflective tool for existing practices and an information-gathering framework.

Acknowledgments

We extend our sincere thanks to the children and the schools for their openness and enthusiastic participation. The children's shared play experiences were invaluable to this research. We also thank the anonymous reviewers for their thoughtful feedback. The first author is grateful to David Randall for the valuable discussions during the early stages of this work. This work was supported by the Portuguese Foundation for Science and Technology (FCT): 2022.06596.PTDC, 10.54499/LA/P/0083/2020, UID/50009/2025, 2024.15729.PEX, UID/00408/2025, and by the European project DCitizens: Fostering Digital Civics Research and Innovation in Lisbon (GA 101079116),

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